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The cost-price SQUEEZE

...and what can be done about it p. 93

WORLD OIL

SPECIALIZED FOR EXPLORATION, DRILLING AND PRODUCING OPERATIONS AND MANAGEMENT

NOVEMBER 1959

Mid-Continent's hottest area 113
Improve LACT performance 129
New additives aid cementing 140
How to use gravity data 143
South America's oil future 150

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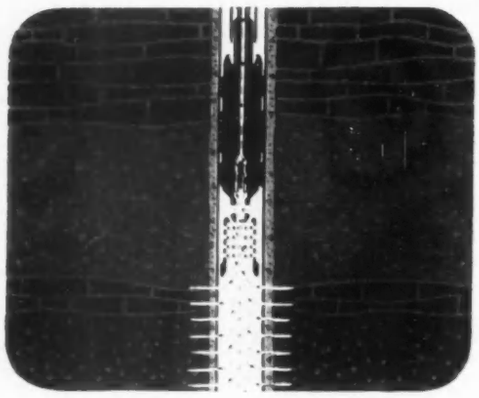

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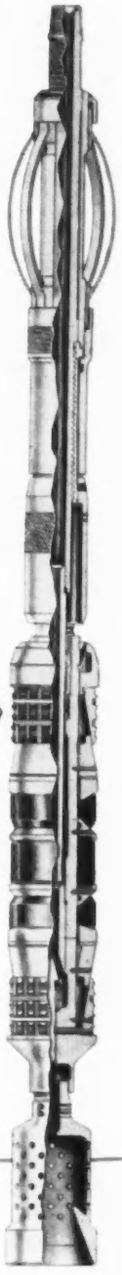

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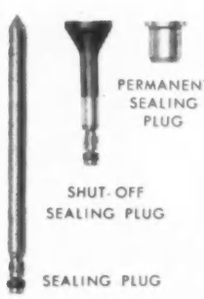

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VOLUME 149, NO. 6 NOVEMBER 1959

WORLD OIL

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SPECIALIZED FOR EXPLORATION, DRILLING AND PRODUCING OPERATIONS AND MANAGEMENT

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a Quick Look at this issue . . .

BUSY OIL MEN: To help you put first things first, scan these time-saving digests on this and the following pages, checking ☑ those you want to read first

☐ **New activity in Southwest Kansas-Oklahoma Panhandle** . . . Several factors are contributing to the upsurge in exploration and development activity in this area—particularly in Beaver County, Oklahoma, and in Seward and Meade counties, Kansas. For complete details, including a discussion of the area's potential, geology, drilling conditions and production data—plus two excellent maps and a cross section chart—turn to **Page 113.**

☐ **How to handle high strength drill pipe** . . . Increased drilling depths and higher strength drill pipe have brought about improvements in hoisting systems. Several new methods have been used successfully. Other methods have been proposed. These are cutting down notch fatigue in deep drilling operations. How these new hoisting methods are being used and the advantages are discussed in an article beginning on **Page 117**

☐ **Here's how to improve your gas lift installations** (Part 3) . . . Gas requirements for intermittent gas lift, which include chamber installations and most fluid-operated installations, are "musts" for sizing closed rotative gas lift systems or for computing lifting costs for comparison with other types of artificial lift. Several methods can be used to calculate these requirements, but the volumetric method is believed best for the job. This installment presents an easy-to-use chart which allows graphical determination of daily gas requirements for intermittent wells when basic field data are known. . . . . **Page 120**

☐ **Can equipment leasing cut production costs?** . . . How does leasing work? Does it save producers money? How? For the answers to these provocative questions, plus two excellent case histories showing how producers benefit from leasing, turn to. . . . . **Page 123**

☐ **Preventing equipment failure in sour-gas condensate wells** . . . Two of the major problems in producing sour gas-condensate wells has been the economic and personnel hazards caused by spontaneous failure of well equipment. Hydrogen sulfide stress corrosion cracking has been responsible for these failures. Shell Oil Company has reduced the probability of such failures to a minimum by determining the corrosivity of each new well stream and is using this information to select proper resistant equipment and appropriate completion practices. For a complete discussion of Shell's method, turn to. . . . . **Page 125**

Why a report on the cost-price

FROM THE OIL AND GAS industry's beginning, operators have been concerned with rising costs and adequate prices in their efforts to make a fair profit. More so during some periods than others.

Don E. Lambert

1958-1959 has been one of the "more so" periods.

Already hard hit by an oversupply of crude oil that resulted from meeting the 1957 Suez crisis, the industry's economic problems were compounded by the 1958 business recession.

Many of last year's problems have continued into 1959: Oversupply and excessive productive capacity continue to plague the industry—demand is not keeping pace with previous patterns of increase—low-price foreign crude oil continues to put downward pressures on prices—taxes, equipment and personnel costs are increasing—federal control of natural gas prices is as stifling as ever and new attempts to cut the 27½ percent depletion provision probably lie ahead—plus ever-present competition from alternative fuels—all of these are putting, or threatening to put, a tighter lid on industry returns from capital investment.

Industry concern over downward pressures on prices and upward pressures of rising costs, with profits squeezed in the middle, is substantiated by the fact that five major oil and gas economic studies have been completed within the past 12 months—more than at any previous time in the industry's history. Acquisitions, mergers and reorganizations are more numerous than in previous years.

This is why the WORLD OIL staff has spent the past several months studying the oil and gas industry's economic position—and ways in which it can be improved. From this research has come the first comprehensive report to be published on the

☐ **How to improve LACT performance** . . . A recently developed instrumentation package composed of a BS&W monitor, integrator, gravity transducer and temperature transducer has been designed especially for LACT service. The complete data readout system provided makes possible 30-day unattended lease operation. Also, sample storage problems are eliminated and losses associated with manual determination of BS&W content and API gravity are prevented. . . . . **Page 129**

☐ **Geologist's interpretation of drilling mud requirements** (Part 1) . . . reviews many of the prepared muds in current use, studies their properties and composition and describes their effect on various logging methods. In addition, a logging method is proposed which the author believes will yield optimum evaluation for each type of drilling mud. . . . . **Page 133**

☐ **How to cross-check accuracy of velocity and seismic data** . . . Instrumental and operational factors can cause errors in interpreting velocity and seismic reference shot data. Alignment of the sonde in the hole, spacing, and hole enlargement affect velocity log data accuracy. Comparison of seismic reference time shots with total log times from 25 velocity log surveys over a widespread area showed that 84 percent tied to within 3.5 percent error or better. . . . . **Page 137**

☐ **How new additives improve deep well cementing** (Part 1) . . . Phillips Petroleum Company drilled three deep tests in Pecos County, Texas, during 1958. Several new records were set and technological

Continued on Page 6

squeeze?

industry's many-faceted cost-price squeeze. Here is what you will be reading in the special report, starting on Page 93:

- For the first time, five major economic studies have been condensed into a single package—for comparison purposes and so WORLD OIL subscribers can see the complete picture, rather than fragments. See Page 94.
- Three downward pressures and six upward pressures on crude oil prices are presented on Page 99.
- Ways in which applied technology can help reduce rising costs are discussed on Page 101.
- How one company determines cost is described on Page 107.
- Not included in the report, but of top interest to those looking for cost-cutting ideas is "Can Equipment Leasing Cut Production Costs?" starting on Page 123.

Don E. Lambert
Associate Editor

Oil Industry In Brief

Here are the latest economic trends, revealed by WORLD OIL *and industry statistics:*

On the plus side

Crude stocks hold steady. On September 30 crude stocks totaled 251 million barrels (31.7 days' supply)—the smallest inventory in recent years . . . See Page 25.

Refinery runs curtailed. Crude runs to stills averaged 7.9 million barrels daily in September, compared with 8.1 million barrels daily in August—decrease mostly was in runs of domestic crude . . . See Page 25.

Demand increases. Although below earlier predictions, September petroleum demand was up 2.1 percent over September 1958 (down about 1 percent from August 1959). Demand for first nine months was up 5 percent over 1958 . . . See Page 25.

Rig total up slightly. September 30 rig total was up 109 rigs or 2.6 percent over 4,118 rigs operating on same date in 1958 . . . See Page 28.

Offshore activity may increase. Pending favorable Supreme Court decision on Tidelands Issue this Fall, predictions are for an upsurge in offshore drilling next year. So far in 1959, operators have spent $143 million to lease nearly 140,000 acres of marine inland and offshore acreage . . . See Page 13.

On the minus side

Well completions drop. During September, new well completions averaged 133 wells per day—4.3 percent under August average and 5.7 percent under September 1958 average . . . See Page 28.

Footage decreases. An average of 573,333 feet per day was drilled during September, down 2.9 percent from August. And August average was down 2.1 percent from 603,236 feet per day drilled during July . . . See Page 28.

Oversupply continues. Inventories of all oils were up 10 million barrels or 327,000 barrels daily on September 30, compared with August's end. Most of the increase resulted from imports of crude and refined oils . . . See Page 25.

Prices are weak. Petroleum prices have dropped more than 10 percent since 1957, while wholesale prices for all commodities other than food have increased 2 percent . . . See Page 13.

QUICK LOOK at this issue . . .

advances recorded while drilling these wells. Cementing practices were unique because of great depths and high temperatures. A complete discussion of cementing practices on these wells starts on . . . . . **Page 140**

☐ **How to correct and interpret gravity data** . . . The most important corrections of gravity data in exploration are latitude and elevation (free air and Bouguer) corrections. Terrain, regional and other corrections of lesser importance should be considered also. Geophysicists should avoid over-reliance on arbitrary mechanical interpretive techniques; instead, should analyze gravity anomalies by examining their individual components through geological and geophysical reasoning. In turn, geologists can be more selective and less arbitrary in the way gravity anomalies are used for incorporation into regional subsurface maps . . . . . **Page 143**

☐ **Eighty-acre spacing sufficient to deplete primary oil** . . . Here is a case history of the Pettit lime reservoir in Horsehead field, Arkansas. Wider well spacing provided excellent primary recoveries and now serves for waterflood operations in the field . . . . **Page 146**

☐ **Oil search under way in vast interior South America** . . . Possibilities in Brazil, Bolivia and Peru have barely been scratched. The remoteness of most of the prospective areas of these nations has retarded development, but much has been learned of the geology to guide oil exploration. Illustrated with generalized sedimentary columns for each area of interest and by maps published with the first part of this series (WORLD OIL, September 1959), this is the third of four exclusive WORLD OIL articles on South America . . . . . **Page 150**

Be sure to watch for . . .

Your January and February 1 issues of WORLD OIL will present a completely new technical-operating Production Practices Manual—directed specifically to oil and gas operators concerned with all types of producing gas wells.

You can be doubly sure this manual will be current, correct and complete. Reason: The WORLD OIL staff has spent the past six months working closely with many of the industry's most highly respected equipment authorities in preparing this special, top interest presentation.

Here is a brief preview of what you will be reading in WORLD OIL's first Production Practices Manual:

- Conventional oil and gas separators
- Glycol dehydrator
- Calcium chloride dehydrator
- Long cycle dry desiccant dehydrator
- Low temperature separation unit
- Short cycle, dry desiccant dehydrator and hydrocarbon recovery unit
- Ammonia absorption refrigeration unit as applied to low temperature separation.

Thus, as in the past, WORLD OIL will start 1960 with the most current and reliable technical-operating information that can be obtained.

WORLD OIL

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WORLD OIL (formerly The Oil Weekly) and The COMPOSITE CATALOG for the drilling-producing industry.
PIPE LINE INDUSTRY and The PIPE LINE CATALOG for the oil and gas pipe line industry.
PETROLEUM REFINER and The REFINERY CATALOG for the oil, gas and petrochemical processing industry.

Indexed by Industrial Arts Index and Engineering Index

Looking Ahead

New statistics on cost-price squeeze . . . Three industry sources recently spoke their piece on problems involved and ways to combat tightening cost-price squeeze:

Independent Petroleum Association of America—petroleum prices have dropped more than 10 percent since 1957, while wholesale prices for all commodities other than food have increased 2 percent. One solution to vise-like pressures on profits: Restore petroleum prices to levels that reflect increasing costs.

American Association of Oilwell Drilling Contractors—about 1,000 contractors are now in the drilling business, owning 3,400 rigs. However, there is current demand for only 2,200 rigs. Contract prices are sliding steadily downward. Reasons: Since World War II, reserves increased too fast, too many rigs were bought, better methods and equipment were developed, drilling operations were conducted as if boom would never end. Possible solutions: Increase penetration rates—develop new and improved techniques and equipment—concentrate on more efficient, economical operations.

Standard Oil Company of New Jersey—announces immediate plans to cut back capital expenditures for at least two years, improve programing techniques and to rely in some measure on supplementary product purchases from other suppliers. Result will be smaller margin of reserve capacity to meet business fluctuations.

Oil country steel supply dwindles . . . Oversupply, excessive productive capacity and weak price structures are having greater effect on drilling activity than steel shortage. However, this situation may not continue.

Steel experts predict it will take up to 90 days after Taft-Hartley order before adequate supplies of steel products are available. And some forecast another strike may be in the offing.

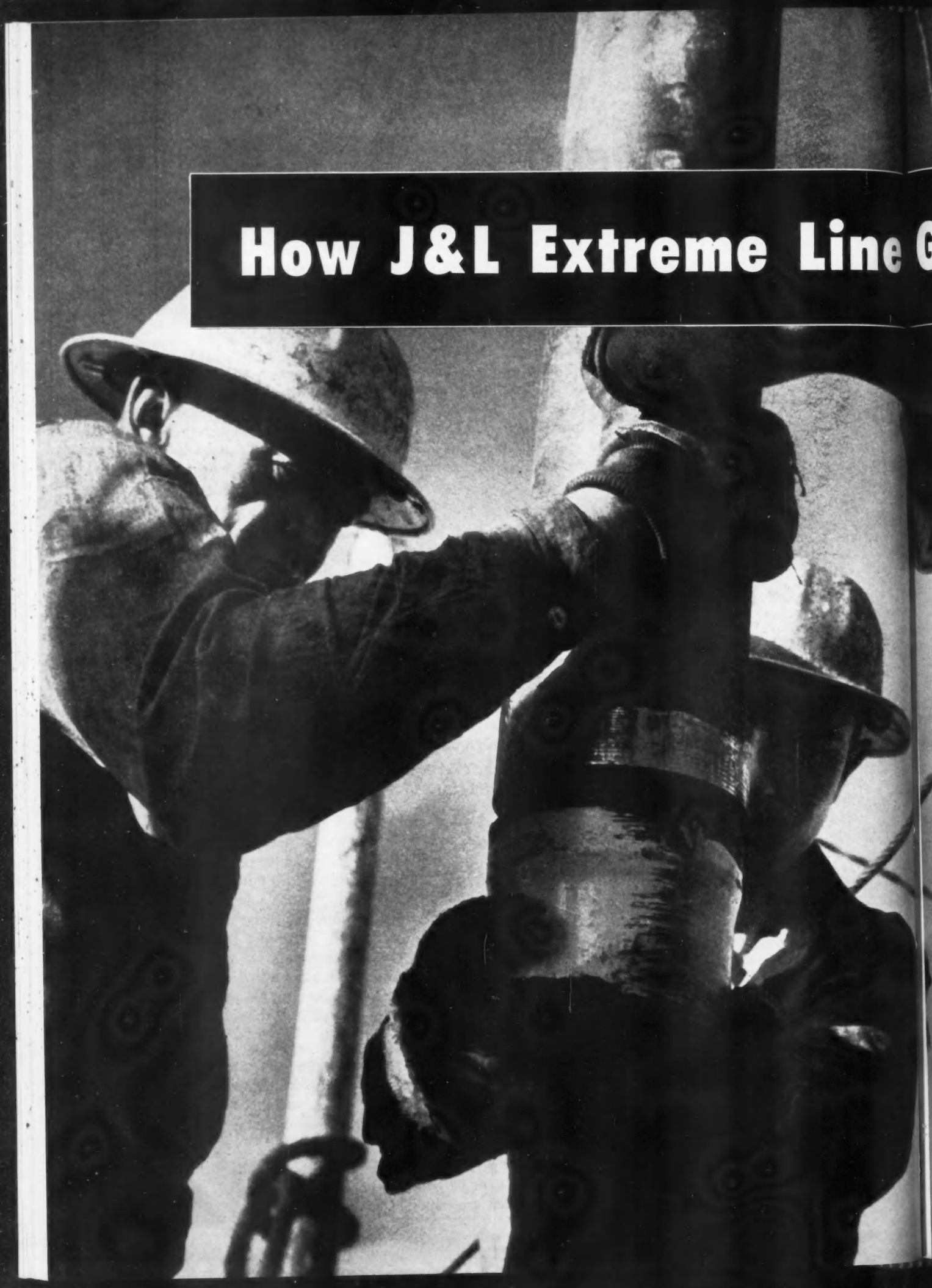
Meanwhile, high-grade large diameter casing already is in short supply, causing delays in deep drilling programs. Also, fast-growing trend toward multiple completions is being slowed by acute shortages of 2⅜ and 2⅞-inch tubing.

Look for full impact of steel strike to hit oil industry after January 1.

Looking ahead in Washington . . . One bright ray in oil industry's future is prospect for upsurge in offshore drilling during 1960; however, everything hinges on Supreme Court decision this Fall as to what "offshore" is, who owns offshore areas and how far out. Interesting offshore note: Operators have paid out more than $143 million for nearly 140,000 acres of inland marine and offshore acreage in three lease sales held so far this year . . . **Interior Secretary Seaton has asked oil and gas industry to submit new natural gas bill,** preferably in 1961, indicating that if certain requirements are met, administrative support can be expected no matter what party is in office . . . **Independent Natural Gas Association has blasted coal interests' proposal for a National Fuels Policy** as being against the best interest of the nation—aimed at oil and gas to strengthen coal's position—and implying that some fuels are running out of reserves.

Can built-in casing perforators cut completion costs? . . . After 11 field tests, new passive permeator well completion method probably will appear on the market this Fall. Method uses "permeator"—a series of short, telescoping tubes run on tubing or casing in collapsed position that are forced outward by hydraulic pressure when opposite producing formation.

Estimated cost for each permeator is $15—from $5 to $8 more than bullet perforation and $4 to $7 more than jet perforation. However, reduced down-time and increased treating efficiency are expected to equalize initial costs.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J&L Extreme Line integral joints are streamlined inside and out. The relatively light external upset decreases the possibility of hanging up — you can safely run this casing through packers under pressure.

You get fast, trouble-free running-in speeds. You stab easily, and you cannot cross-thread. You make up with five to seven turns with the spinning line and less than one turn with the tongs.

You get *everything* in *J&L Extreme Line* made under license from The National Supply Company — high strength in tension, burst and collapse — *and* leak resistance! *This is casing that can be salvaged and rerun repeatedly.*

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Good Wells Make Good News

A Monthly Report On Wells That Are Now Worth More

November, 1959

Many operators want to know just how jobs engineered with the aid of the "Frac Guide"* compare with others. It will be many months before the full story is available, but these four cases will give an idea.

- **Pembina Area, Alberta, Canada** (New Oil Well) This well was completed into the Cardium through perforations between 4187 and 4204 feet. Porosity was 13 per cent and permeability was 3.8 millidarcies. Using the "Frac Guide", Dowell recommended Sandfrac*. 25,000 gallons lease crude and 68,000 pounds sand were injected at 15 bpm. Result: Gas-oil ratio dropped. Production tested at 46 bopd flowing. Allowable is 33 bopd. Well has continued to flow with no drop in production, although offsetting wells fractured without the aid of the "Frac Guide" usually have to be put on the pump after producing about one month.

- **Lea County, New Mexico** (Old Oil Wells) Two offsetting wells were completed open hole into the Grayburg at about 4100 feet. Production had declined and operators decided to fracture both wells. One well was treated without the aid of the "Frac Guide". 15,000 gallons lease crude and 15,000 pounds sand were injected down casing. Production rose initially, but dropped to about 5 bopd after 120 days. Treatment for the other well was engineered with the "Frac Guide". 20,000 gallons refined oil and 50,000 pounds sand were injected down 3-inch tubing. Production rose to 90 bopd, flowing. After 120 days, it was still 45 bopd, flowing.

- **Ashtabula County, Ohio** (New Oil and Gas Well) This well, completed open hole into the Clinton sand (3135 to 3140 feet), made only a show of oil and gas before treatment. The "Frac Guide" was used to engineer a treatment with over twice the concentration of sand per gallon of fluid previously used in this area. 16,000 gallons fresh water with FLA* (Fluid Loss Additive) carried 32,000 pounds sand into the formation. Treatment was down 5½-inch casing at 34 bpm. After clean-up, well made 1000 mcfd and 25 bopd. It was the best well in the area.

- **Beaver County, Oklahoma** (New Gas Well) The lower Morrow sand was perforated from 7214 to 7245 feet. Well made only a show of gas after being cleaned up with 500 gallons Mud Acid. The "Frac Guide" indicated that Waterfrac should be used. 20,000 gallons gelled water and 59,000 pounds sand were pumped down 4½-inch casing at 39 bpm. After clean-up, well made 9900 mcfd on State test.

Take advantage of Dowell's experience with the "Frac Guide" to help you get more profit from your operations. For service or detailed information, contact the Dowell office or station nearest you. There are more than 165 locations in the United States, Canada, Venezuela and Argentina. Dowell, Tulsa 1, Oklahoma.

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Services for the oil industry DOWELL

DIVISION OF THE DOW CHEMICAL COMPANY

Reliable cost data needed

● U.S. RESERVES of oil and gas are at an all-time high, with a more-than-adequate working inventory in terms of current requirements. The current availability of crude in the United States is in excess of 3 million barrels per day above present production.

● Discoveries of new petroleum reserves can keep pace with increasing domestic requirements for a long period. In the next 20 years, with allowance for increased recovery due to improved techniques, a minimum of 70 billion barrels of crude oil supply can be added above the 30 billion barrels now estimated.

● Reasonable cost of domestic oil and gas, compared with other sources of energy, can be maintained so long as the industry continues its technological progress and so long as it operates as efficiently as possible through the assistance of regulatory agencies.

THESE CONCLUSIONS are underscored in five major oil industry economic reports with the full realization that the oil industry has, is and will experience serious economic problems as it progresses. Currently, these problems include, among others, excessive productive capacity, oversupply, low cost foreign oil, and raising costs.

As in most other industries, the oil and gas industry has its purveyors of doom (the U.S. is running out of crude oil reserves; oil will soon price itself out of the market) . . .

. . . the middle-of-the-roaders (we are doing all right, "but") . . .

. . . and the optimists (we have whipped our problems in the past and will continue to do the same in the future).

WHAT IS THE TRUE PICTURE? An integral part of this answer lies in an accurate, comprehensive and over-all study of oil and gas industry economics which could be available to all concerned. But the study assuredly would have to be based on adequate cost information.

Such information is not currently available. And there are those who say it never will be.

This unfortunate situation exists despite the fact that reliable cost data are urgently needed if the industry is to accurately chart its future course of economic action and if the public and various governments are ever to fully understand industry problems.

For any secondary recovery method ...look to Gardner-Denver equipment

Water flooding

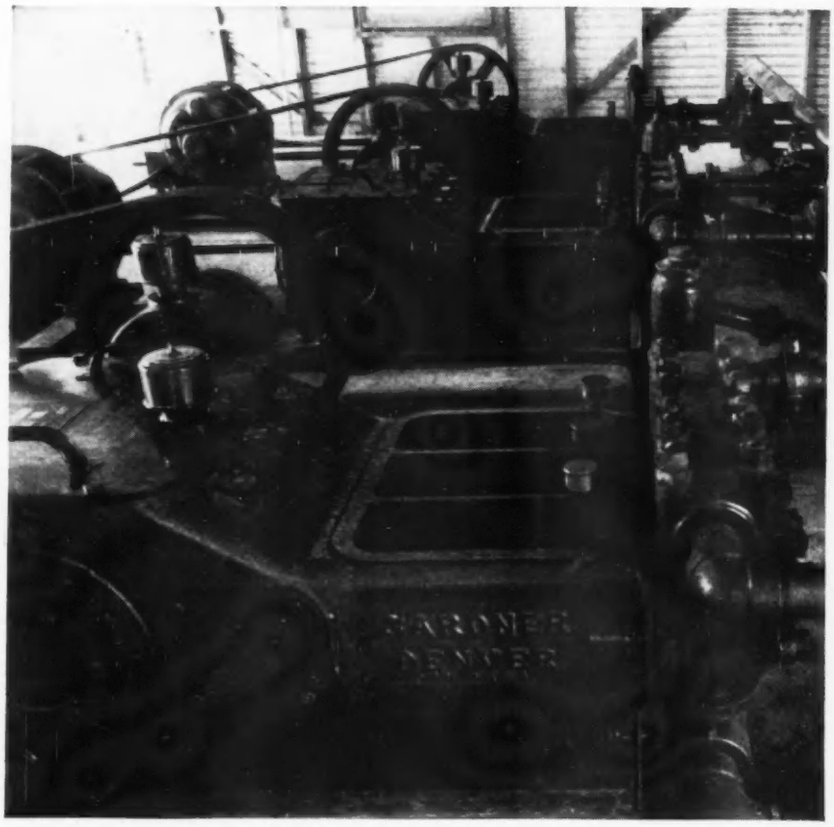
Gas injection

Miscible phase

In situ combustion

Vacuum maintenance

Gas slug drive



RESEARCH TAKES A LONG VIEW

At the start of our second century Gardner-Denver men are calling on the knowledge and experience of a century of progress to develop new and better ways of helping the men of industry, construction, mining and petroleum multiply productiveness and build a better world.

In oil company laboratories Gardner-Denver secondary recovery specialists work side by side with petroleum engineers to develop pilot plant equipment. On field tests Gardner-Denver men and equipment help work out practical applications.

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Surpluses remain despite curtailment

Distillate, residual and gasoline stocks represent more days' supply than in 1955

THE INDUSTRY has continued to try with some success to improve its oversupply situation. In September it held production of crude oil and natural gas liquids to approximately the same levels as in August. But imports of both both crude and refined oils were increased, partially canceling the benefits of the curtailment of domestic production.

Meanwhile, the industry materially cut refinery runs of crude, to 7,913,000 barrels daily in September from 8,106,000 daily in August. The reduction was made mostly in runs of domestic crude.

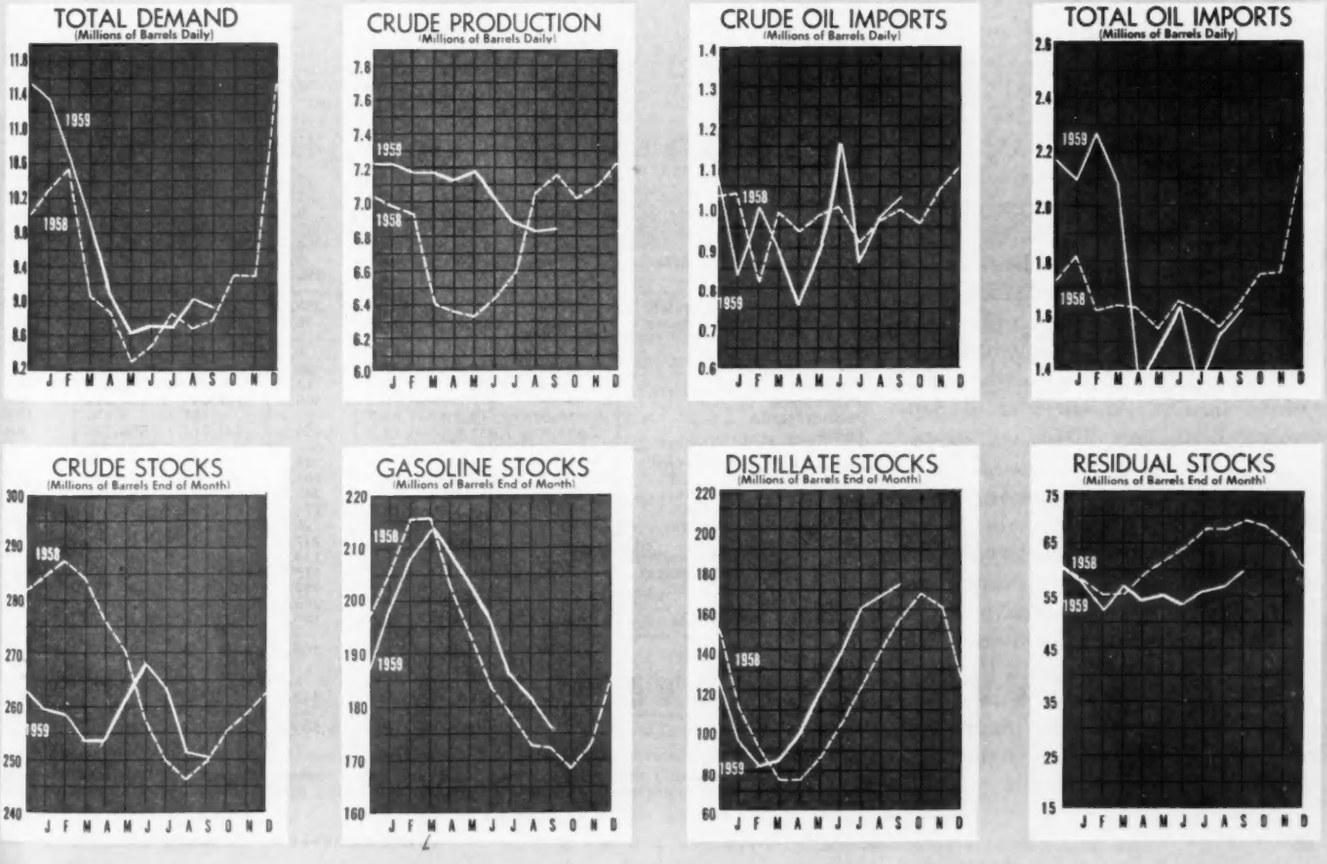
Demand for petroleum in September was down seasonally about 1 percent from August, but it was up 2.1 percent over September last year. The September experience indicates that demand for oil is not as strong currently as it was in earlier months. For the first 9 months of 1959, total demand showed an increase of 5 percent over 1958.

Thus the industry's efforts to eliminate oversupplies and surpluses are now being made more difficult than in past months by a less favorable demand trend.

Stocks. The trends of supply and demand in September were such that there was an increase of 10 million barrels, or 327,000 barrels daily, in stocks of all oils. That was considerably more than the 145,000 barrels per day added to storage in August, although less than the 738,000 daily added in September last year.

Stocks of all oils at the end of September 1959 totaled 834.2 million barrels, compared with 824.4 million

Petroleum Trends...



at the end of August and 816.7 million at the end of September 1958. The stocks are 2.1 percent greater than a year ago, and though demand also is up at least that amount, the year-ago stocks were excessive, indicating a continuing surplus.

To determine the proper levels for stocks, they must be measured in terms of days' supply that they represent at prevailing rates of demand, and current supplies must be compared with those held in prior years. Such a study of stocks back to 1955, a good year for the industry, indicates that if all stocks were put on the same basis as in 1955 in terms of days' supply, the total of all oils would have to be cut 35 million barrels to slightly under 800 million barrels. They would then represent about 89 days' supply, whereas the actual September 30 stocks of 834 million barrels were equivalent to 92.7 days' supply.

The present surplus consists wholly of refined products, as September 30 crude stocks of 251 million barrels or 31.7 days' supply represented a smaller inventory than in any other recent year, including 1955. To equal the 34 days' supply held at end of September in 1955, the crude stocks would have to be increased 16 million barrels to 267 million.

Gasoline stocks, however, were 9 million barrels larger on September 30 than if they had been on a 1955 basis. The stocks of 176.6 million barrels represented 40.8 days' supply. If they had totaled only 38.7 days' supply as at end of September 1955, they would have amounted to 167 million barrels.

Distillate fuel oil stocks, similarly, were 23 million barrels larger on September 30, 1959, than if on a 1955 basis of days' supply. They totaled 173.9 million barrels or 125.3 days' supply. If they had been only 108.4 days' supply as on September 30, 1955, they would have totaled 150.5 million barrels. At the end of September 1956, only 104 days' supply of distillate was held. Thus distillate stocks appear more excessive than those of any other oil.

Residual fuel oil stocks of 59.5 million barrels or 46.8 days' supply on September 30 were excessive by 16 million barrels by the 1955 standard. September 30 stocks in both 1955 and 1956 were equivalent to 34 days' supply. This year, end of September stocks of 34 days' supply would have totaled 43.6 million barrels.

U.S. Petroleum Demand and Supply (Thous. Bbls. Daily)

ITEM	September 1959	September 1958	% Diff.	Aug. 1959	January-September 1959	January-September 1958	% Diff.
DEMAND							
All Oils, Total Demand	8,994	8,807	+ 2.1	9,078	9,550	9,097	+ 5.0
Domestic Demand	8,744	8,513	+ 2.7	8,823	9,299	8,819	+ 5.4
Export Demand	250	294	—15.0	255	251	278	— 9.7
Gasoline, Total Demand	4,325	4,097	+ 5.6	4,333	4,150	3,964	+ 4.7
Distillate, Total Demand	1,388	1,321	+ 5.1	1,125	1,745	1,705	+ 2.3
Kerosine, Total Demand	256	203	+26.1	215	282	283	— 0.4
Residual, Total Demand	1,271	1,328	— 4.3	1,265	1,589	1,460	+ 8.8
Other Oils, Total Demand	1,757	1,858	— 5.4	2,140	1,784	1,685	+ 5.9
CHANGE IN STOCKS							
All Oil, Change in Stocks	+327	+738	.....	+145	+161	—85	.....
NEW SUPPLY							
Total New Supply	9,321	9,545	— 2.4	9,223	9,711	9,012	+ 7.8
Domestic Production, Total	7,700	7,899	— 2.5	7,685	7,933	7,382	+ 7.5
Crude Oil	6,825	7,099	— 3.9	6,810	7,064	6,600	+ 7.0
Natural Gas Liquids	875	800	+ 9.4	875	870	782	+11.2
Imports, Total	1,621	1,646	— 1.5	1,538	1,777	1,630	+ 9.0
Refined Products	598	649	— 7.9	561	817	689	+18.6
Crude Oil, Total	1,023	998	+ 2.5	977	960	940	+ 2.1
Crude, East Coast	784	779	+ 0.6	680	740	764	— 3.2
CRUDE RUNS							
Crude Runs to Stills	7,913	7,763	+ 1.9	8,106	8,024	7,536	+ 6.5
Domestic Crude	6,929	6,828	+ 1.5	7,118	7,071	6,607	+ 7.0
Foreign Crude	984	935	+ 5.2	988	953	929	+ 2.6

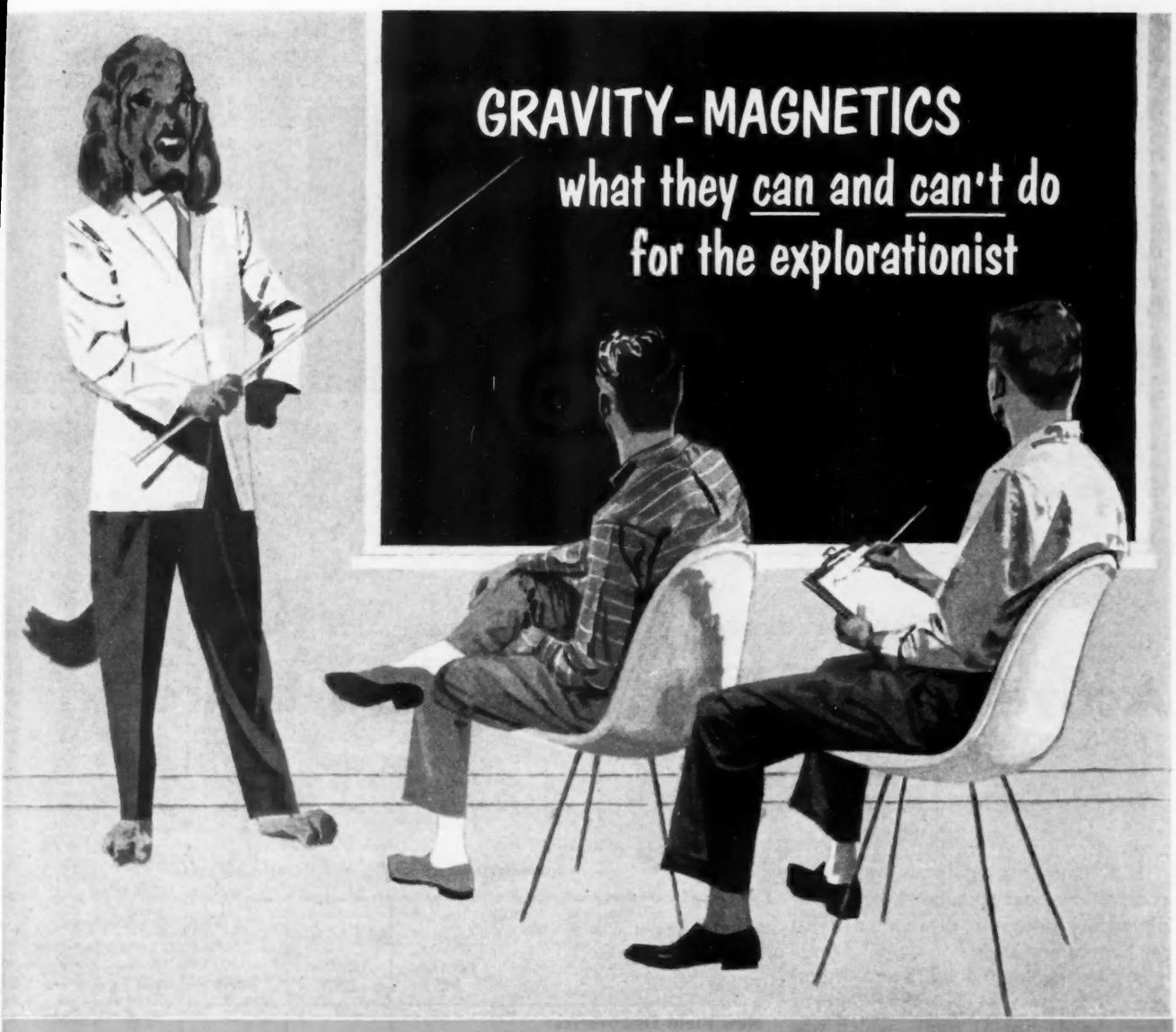
U.S. Stocks of Oils (Million Bbls. at End of Month)

KIND OF OIL	TOTAL IN U.S. Sept. 1959	TOTAL IN U.S. Sept. 1958	TOTAL IN U.S. % Diff.	TOTAL IN U.S. Aug. 1959	EAST OF CALIFORNIA Sept. 1959	EAST OF CALIFORNIA Sept. 1958	EAST OF CALIFORNIA % Diff.	EAST OF CALIFORNIA Aug. 1959
All Oils	834.2	816.7	+ 2.1	824.4	.....	.....	.....	.....
Crude Oil	251.0	251.7	— 0.3	252.9	217.1	210.6	+ 3.1	217.7
Gasoline	176.6	175.3	+ 0.7	182.1	151.0	152.0	— 0.7	155.5
Distillate Fuel Oil	173.9	155.4	+11.9	161.6	158.8	141.3	+12.4	146.5
Kerosine	32.2	31.3	+ 2.9	31.2	31.9	31.0	+ 2.9	30.8
Residual Fuel	59.5	67.7	—12.1	57.0	33.0	34.0	— 3.0	30.4
Other Oils	141.0	135.3	+ 4.2	139.6	.....	.....	.....	.....

U.S. Crude Oil Production, by States (Thous. Bbls.)

STATE or DISTRICT	Daily Average for Month Sept. 1959	Sept. 1958	% Diff.	Aug. 1959	Total, January-September 1959	1958	% Diff.
Alabama	15.6	15.7	— 0.6	16.3	3,861	4,365	— 11.6
Arkansas	47.0	75.6	— 37.8	46.7	19,336	21,454	— 9.9
California	838.5	850.0	— 1.4	844.9	230,362	235,936	— 2.4
Colorado	126.8	129.2	— 1.9	127.0	34,410	36,492	— 5.7
Florida	1.2	1.2	.....	1.2	319	337	— 5.4
Illinois	217.9	227.8	— 4.4	210.6	58,566	61,387	— 4.6
Indiana	32.1	30.5	+ 5.2	32.1	9,044	8,692	+ 4.0
Kansas	314.7	335.1	— 6.1	308.0	89,102	87,593	+ 1.7
Kentucky	73.9	50.0	+ 47.8	90.8	20,892	12,207	+ 71.1
Louisiana	993.7	890.8	+ 11.6	1,035.5	262,075	227,722	+ 15.1
North Louisiana	113.7	112.4	+ 1.2	114.2	32,794	31,327	+ 4.7
South Louisiana	880.0	778.4	+ 13.1	921.3	229,281	196,395	+ 16.7
Michigan	30.1	26.1	+ 15.3	27.8	7,459	6,931	+ 7.6
Mississippi	141.4	111.0	+ 27.4	137.7	34,952	27,748	+ 26.0
Mo.-So. Dak.-Tenn.	0.5	0.3	+ 66.6	0.5	57	96	— 40.6
Montana	81.9	79.2	+ 3.4	81.8	22,400	21,044	+ 6.4
Nebraska	66.7	57.8	+ 15.4	64.6	17,132	15,023	+ 14.0
Nev.-Wash.-Alaska-Ariz.	0.5	0.1	+400.0	0.5	144	31	+364.5
New Mexico	297.1	271.9	+ 9.3	286.4	78,823	72,892	+ 8.1
Southeast New Mexico	251.0	243.9	+ 2.9	250.0	68,173	67,351	+ 1.2
Northwest New Mexico	46.1	28.0	+ 64.6	36.4	10,650	5,541	+ 92.2
New York	5.1	3.0	+ 70.0	5.4	1,468	1,405	+ 4.5
North Dakota	53.0	25.0	+112.0	40.9	13,293	10,859	+ 22.4
Ohio	14.1	17.7	— 20.3	13.6	4,140	4,732	— 12.5
Oklahoma	501.9	561.3	— 10.6	506.8	147,031	151,214	— 2.8
Pennsylvania	16.0	19.2	— 16.7	15.4	4,457	5,136	— 13.2
Texas	2,493.9	2,888.5	— 13.7	2,454.3	743,713	686,227	+ 8.4
Dist. 1: South Central	44.0	48.4	— 9.1	44.7	12,403	12,541	— 1.1
Dist. 2: Middle Gulf	110.3	134.8	— 18.2	106.5	32,554	30,802	+ 5.7
Dist. 3: Upper Gulf	350.0	401.7	— 12.9	349.6	105,602	101,571	+ 4.0
Dist. 4: Lower Gulf	177.8	219.1	— 18.8	175.9	52,756	50,817	+ 3.8
Dist. 5: East Central	28.6	34.1	— 16.1	28.2	8,297	8,110	+ 2.3
Dist. 6: Northeast	242.8	299.0	— 18.8	237.2	73,033	68,851	+ 6.1
Dist. 7-B: North Central	132.5	153.8	— 13.9	130.2	43,919	36,996	+ 18.7
Dist. 7-C: West Central	117.7	148.1	— 20.5	115.9	35,422	35,585	— 0.5
Dist. 8: West	977.1	1,107.6	— 11.8	950.6	291,831	250,993	+ 16.3
Dist. 9: North	203.2	212.9	— 4.6	205.9	56,630	53,731	+ 5.4
Dist. 10: Panhandle	110.0	107.8	+ 2.0	109.6	29,418	29,075	+ 1.2
Utah	107.6	98.8	+ 8.9	109.6	30,138	15,990	+ 88.5
Virginia	.....	.....	.....	.....	4	5	— 20.0
West Virginia	6.1	6.7	— 9.0	6.0	1,624	1,643	— 1.2
Wyoming	347.7	326.6	+ 6.5	345.2	93,548	84,644	+ 10.5
Total, U.S.	6,825.3	7,099.1	— 3.9	6,809.6	1,928,350	1,801,805	+ 7.0

Sources for above 3 tables: Bureau of Mines monthly reports, except last two months based on API and B. of M. weekly reports and WORLD OIL estimates, and all Texas district data from API.



an old dog can teach you new tricks!

"Dog-eared" is a term sometimes applied to gravity and magnetics as exploration tools, but these "old guard" methods of exploration can teach many of us new tricks about getting certain prospects surveyed quickly, efficiently and economically.

A number of tails began wagging after explorationists stood up on their hind legs and took a new sniff at prospects via the gravity-magnetics route. If you are interested in cutting costs, while answering specific geologic questions, give us a whistle and we'll trot out our new Bulletin GM59-1, **"Gravity-Magnetics . . . what they *can* and *can't* do for the explorationist."**

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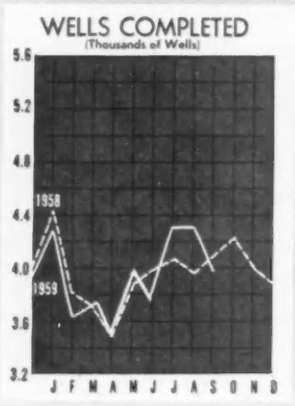
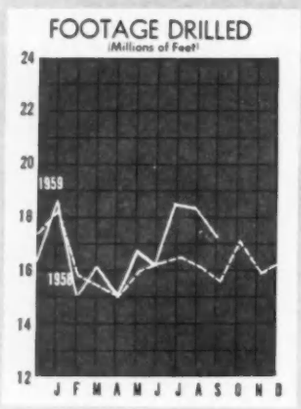
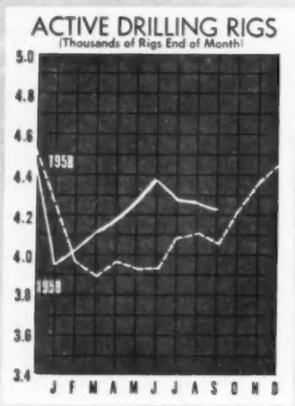
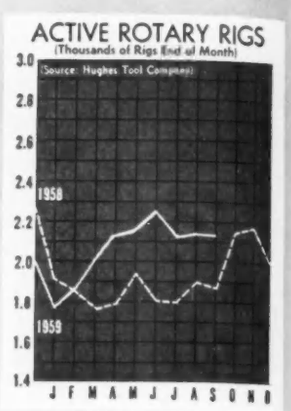
Drilling Activities...









Active rigs up 2.6% over 1958 figure

U.S. DRILLING rig totals, new well completions and footage drilled completed a two-month downward trend on September 30.

Active rigs totaled 4,227 at September's end, down 50 rigs or 1.2 percent from the August 31 total—which was down 73 rigs or 1.3 percent from the 4,290 rigs operating at the end of July. However, the September rig total was up 109 rigs or 2.6 percent over the 4,118 rigs operating on September 30, 1958.

New well completions dropped off in September, averaging 133 wells per day or 4.3 percent under the 139 wells per day completed during August—and 5.7 percent under the 141 wells per day average reported for September 1958.

Footage drilled averaged 573,333 feet per day during September, down 16,990 feet per day, or 2.9 percent under the August average of 590,323 feet. Also, the August average was down 2.1 percent from the 603,236 feet per day drilled during July.

Operators drilled 7,232 wildcats during the first nine months of 1959, down 11.3 percent from 8,154 wildcats drilled during the same 1958 period.

Summary of U.S. Wildcat Drilling

ITEM	September 1959	August 1959	NINE MONTHS January-September 1959	1958	% Diff.
New Field Discoveries:					
Oil	58	75	537	607	— 11.5
Distillate	8	8	72	76	— 5.3
Gas	28	14	187	192	— 2.6
Total Discoveries	**94**	**97**	**796**	**875**	**— 9.0**
Dry Wildcats	**732**	**851**	**6,436**	**7,279**	**— 11.6**
Total Wildcats	**826**	**948**	**7,232**	**8,154**	**— 11.3**
Percent Productive	11.4	10.2	11.0	10.7	.....
Percent Dry	88.6	89.8	89.0	89.3	.....

Summary of U.S. Drilling Activity

ITEM	September 1959	August 1959	NINE MONTHS January-September 1959	1958	% Diff.
New Wells Completed:					
Oil	1,856	2,118	18,241	17,938	+ 1.7
Distillate	82	66	624	559	+ 11.6
Gas	364	336	2,986	3,190	— 6.4
Service	60	74	588	922	— 36.2
Dry	1,613	1,698	13,692	13,512	+ 1.3
Total New Wells	**3,975**	**4,292**	**36,131**	**36,121**	**+ 0.0**
Footage Drilled (Million Feet)	**17.2**	**18.3**	**152.1**	**145.4**	**+ 4.6**

U.S. Drilling Activity in September and First Nine Months, 1959-1958

STATE or DISTRICT	TOTAL NEW WELLS COMPLETED AND FOOTAGE DRILLED: DETAILS FOR SEPTEMBER, 1959 — Oil	Dist.	Gas	Dry	Service Wells	TOTAL NEW WELLS — Sept. 1959	Aug. 1959	Sept. 1958	Total Footage September 1959	DETAILS FOR JANUARY-SEPTEMBER — NEW WELLS 1959	1958	Percent Diff.	FOOTAGE 1959	1958	WILDCAT DRILLING IN SEPTEMBER AND FIRST NINE MONTHS, 1959-1958 — DETAILS FOR SEPTEMBER, 1959 — Oil	Dist.	Gas	Dry	Total Wildcats	DETAILS FOR JANUARY-SEPTEMBER — Oil	Dist.	Gas	Dry	TOTAL WILDCATS 1959	1958	DRILLING RIGS IN OPERATION (Rigging up, Drilling, Temp. Shut Down) — Sept. 30 1959	Aug. 31 1959	Sept. 30 1958
Alabama	5			4		9	8	10	86,989	83	61	+ 36.0	745,904	506,068				4	4				27	27	23	8	8	16
Alaska				1		1			11,080	6			72,967					1	1	1			4	5		8	7	
Arkansas	43		2	33		78	64	83	265,850	606	579	+ 4.7	2,030,102	1,932,657			1	13	14	3		7	83	93	116	49	49	46
California	59		8	42	7	116	132	100	574,600	1,066	1,089	— 2.1	5,136,003	5,107,535	1		1	26	28	4		6	209	219	224	137	135	128
Colorado	11		14	36		61	69	67	339,545	554	622	— 10.9	2,931,147	3,214,761	2		4	21	27	17		11	271	299	344	58	60	65
Florida				1		1	1	1	4,186	6	6		48,687	55,809				1	1				6	6	6	2	1	2
Georgia								1		1	1		990	2,915									1	1	1			1
Illinois	66		3	103		172	221	248	352,292	1,530	1,698	— 9.9	3,368,627	3,902,101	2			56	58	10			360	370	450	320	289	305
Indiana	23			58		81	68	94	113,457	645	586	+ 10.1	1,020,453	959,607				27	27	1		1	177	179	157	97	94	105
Kansas	105		10	175	3	293	360	373	1,063,281	2,787	2,697	+ 3.3	10,225,177	9,276,301	11		2	86	99	109		17	725	851	707	295	284	329
Kentucky	135		23	98	3	259	255	231	224,423	2,168	1,658	+ 30.7	1,964,266	1,643,984	1			2	3	9			57	66	58	206	198	119
Louisiana	140	32	28	156	2	358	367	278	2,850,929	2,844	2,566	+ 10.8	22,244,066	20,194,225	2		3	43	48	22	12	11	352	397	429	360	356	331
North Louisiana	62		21	59		142	165	144	525,696	1,088	964	+ 12.9	3,891,915	3,635,868	2		3	18	23	13	1	4	127	145	138	75	70	56
South Louisiana	78	32	7	97	2	216	202	134	2,325,233	1,756	1,602	+ 9.6	18,352,151	16,558,357				25	25	9	11	7	225	252	291	285	286	275
*Gulf of Mexico	22	7		15		44	40	29	474,800	356	384	— 7.3	3,688,548	3,686,808				4	4	1	2	3	21	27	34	64	50	45
Michigan	25		2	30		57	56	24	189,922	423	273	+ 54.9	1,292,552	788,429	1		1	15	17	3		2	103	108	92	99	97	76
Mississippi	20	2	5	38		65	51	30	611,904	485	277	+ 75.0	4,504,856	2,474,747		1		24	25	7	1	2	172	182	115	84	88	57
Missouri				3		3		2	862	12	13	— 7.7	9,901	11,582				3	3	1			9	10	6	2	3	4
Montana	10		2	9	1	22	19	20	106,484	228	223	+ 2.2	1,094,635	1,193,041				6	6	2			64	66	88	52	50	35
Nebraska	21		1	66		88	74	67	519,689	642	487	+ 31.8	3,818,473	2,906,250	4			39	43	31			258	289	223	33	41	35
New Mexico	89		35	27	1	152	166	140	645,326	1,290	1,485	— 13.1	5,365,275	7,003,724	1		2	14	17	30	1	15	144	190	211	142	159	175
Southeast New Mexico	68		1	21		90	93	70	378,576	701	758	— 7.5	3,347,059	3,763,930	1			13	14	22		4	106	132	133	80	76	62
Northwest New Mexico	21		34	6	1	62	73	70	266,750	589	727	— 19.0	2,018,216	3,239,794			2	1	3	8	1	11	38	58	78	62	83	113
New York	10		1	2	6	19	19	23	30,895	169	177	— 4.5	269,475	280,862											98	25	25	42
North Dakota	13			5	7	25	30	27	178,364	334	313	+ 6.7	2,101,478	2,044,781				3	3	12			48	60	7	20	33	40
Ohio	35		26	29		90	83	68	227,899	718	728	— 1.4	1,931,156	1,877,702			1	1	2	5		3	13	21	568	218	218	224
Oklahoma	182	2	32	158	5	379	448	626	1,432,423	4,301	5,372	— 19.9	15,627,686	16,706,705	13		3	56	72	60	10	24	488	582	21	467	478	473
Pennsylvania	12		27	14	6	59	46	73	214,480	442	574	— 23.0	1,480,191	1,701,155			2	7	9			4	15	19	5	177	138	219
South Dakota				1		1	1		8,386	11	5	+120.0	65,278	22,187				1	1	2			5	7	9	5	8	3
Tennessee							3	2		38	22	+ 72.7	45,975	27,725									17	17				
Texas	807	46	104	462	16	1,435	1,568	1,482	6,508,845	13,323	13,124	+ 1.5	58,814,446	55,549,231	16	7	7	246	276	190	47	73	2,561	2,871	3,041	1,029	1,032	978
Dist. 1: South Central	43	1	2	22		68	61	104	179,363	714	745	— 4.2	1,835,226	1,800,931	1			14	15	7		1	226	234	259	37	37	39
Dist. 2: Middle Gulf	19	5	9	23		56	69	56	365,664	590	536	+ 10.1	3,666,265	3,277,857	1	1	2	14	18	9	13	11	181	214	183	61	38	34
Dist. 3: Upper Gulf	29	16	8	41		94	115	84	689,819	908	951	— 4.5	6,518,432	6,063,647		2		19	21	9	21	7	173	210	259	97	94	82
*Gulf of Mexico				1		1			9,251	2	9	— 77.8	20,256	72,271				1	1			1	1	2	7	2	2	1
Dist. 4: Lower Gulf-S.W.	33	18	23	47	2	123	116	90	692,681	1,021	904	+ 12.9	5,532,529	4,655,777	1	2	1	31	35	12	10	9	284	315	360	89	92	53
*Gulf of Mexico				1		1			500	1	7	— 85.7	500	75,300				1	1				1	1	2		1	
Dist. 5: East Central	8	2	2	12		24	11	25	107,043	108	151	— 28.5	580,881	561,546				6	6	1		1	47	49	90	25	13	16
Dist. 6: Northeast	36	2	8	21		67	86	70	366,801	631	628	+ 0.3	3,447,846	3,296,992	2	1	2	12	17	9	1	7	115	132	155	59	61	62
Dist. 7-B: North Central	106	2	8	89	2	207	222	188	677,188	1,813	1,626	+ 11.5	5,795,500	5,229,651	5	1	1	52	59	51	1	10	530	592	575	92	101	76
Dist. 7-C: West Central	45		3	19		67	73	54	334,753	574	588	— 2.4	2,446,329	2,926,445	3			13	16	19		9	151	179	172	68	65	66
Dist. 8: West	285		6	72	5	368	375	366	1,957,788	3,431	3,183	+ 7.8	17,504,884	15,242,083	3		1	47	51	44		5	376	425	394	244	278	275
Dist. 9: North	144		11	82	7	244	313	314	656,655	2,619	2,820	— 7.1	7,337,549	8,113,464				29	29	19		2	394	415	492	162	150	181
Dist. 10: Panhandle	59		24	34		117	127	131	481,090	914	992	— 7.9	4,149,005	4,380,838				9	9	10	1	11	84	106	102	95	103	94
Utah	10		1	13		24	7	21	135,957	211	315	— 33.0	1,174,132	1,756,016				11	11	4		2	50	56	64	34	48	33
Washington				1		1	1	1	8,468	2	5	— 60.0	14,458	25,863				1	1				2	2	4	2	2	1
West Virginia	13		36	13	2	64	82	63	166,255	580	620	— 6.5	1,479,240	1,665,024				1	1				1	1	6	192	246	189
Wyoming	20		3	33	1	57	90	71	320,298	603	522	+ 15.5	3,160,303	2,506,779	3			22	25	13	1	8	198	220	153	93	111	80
Others	2		1	2		5	3	7	21,089	23	23		73,359	104,931	1		1	2	4	1		1	16	18	17	12	19	7
Total United States	1,856	82	364	1,613	60	3,975	4,292	4,233	17,214,176	36,131	36,121	+ 0.0	152.111,258	145,442,697	58	8	28	732	826	537	72	187	6,436	7,232	7,243	4,227	4,277	4,118
Total Western Canada	125		30	45		200	201	206	980,000	1,868	1,912	— 2.3	9,140,150	9,492,586												184	166	207

* Gulf of Mexico wells are included in their respective district totals.

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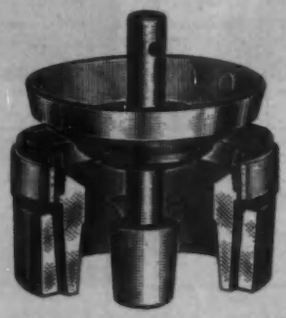

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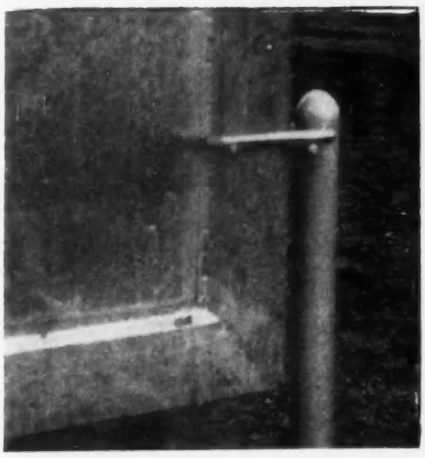


Make Door Stop From Pipe, Sucker Rod

This door stop is made from scrap 2-inch pipe and sucker rod. Close the upper end of the pipe for safety. Drill or burn a hole through the pipe large enough to pass the sucker rod through. Bend the sucker rod as shown in the photograph, with an opening large enough to accommodate the door.

Weld a piece of rod into a horizontal position on the pipe to prevent the holder from dropping off the door. Cut the 2-inch pipe long enough to permit it to be driven into the ground or set in concrete.

Steel Shield on Pump Protects Crew Members

If the stud bolts on the mud pump should fail from fatigue, serious injury could result if they should hit one of the crew members. Consequently, a Gulf Coast contractor has built a solid steel plate as a protective shield on the steam pressure side of the steam pump.

The shield is cut from a ¾-inch sheet of steel, large enough to cover the pressure plates on the pump. It is connected with hinges to the skid so that it may be laid down when it is necessary to work on the pump.

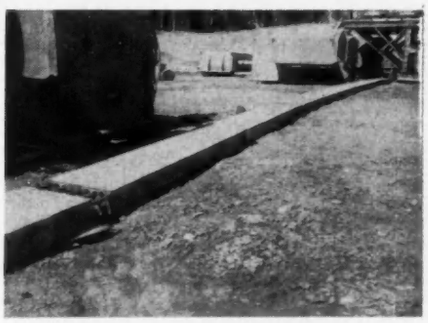
An angle iron brace is welded to the back of the shield to help stabilize it in the upward position.

There are U-shaped handles welded to the front of the shield to facilitate the folding down of the shield.

Measure Lease Pump Gas Consumption

Producers operating in areas where state law requires measurement of all gas used for lease operations, sometimes find it difficult to account for that quantity of gas used to operate fire wall steam pumps. Such pumps utilize gas instead of steam as the operating medium, and, if only one gas system is present on the lease, the pump exhaust must be flared.

This operator has installed an orifice well tester on the pump discharge as shown and is using a recorder to determine flow rate. The recorder can be installed on any type of post or pole to prevent damage. Whenever the lease pump is in operation, the well tester is used to measure that gas discharged by the pump and a permanent record of all gas used may be obtained.



Build Walkway With Steam-Tracer Lines

Steam tracer lines are essential during the winter in the Canadian North country to prevent freezing up of the rig utility line system. One contractor, in simplifying the unitizing of the lines, including tracers, strung them in compartmentized steel boxes which in turn become walkways between the rig, water tanks, fuel and other supply houses on the location.

Utility and steam tracer lines are installed side by side, projecting at each end of a given compartment through a bulkhead. Sufficient space is left between the compartments to enable a man to make up unions connecting the various lines. The compartments are rectangular in cross section, covered with non-skid diamond plate steel plate, and are equipped with lifting ears that make easy work of handling and rigging with the aid of a gin pole truck.

The compartment, being some 6- to 8-inches high in cross-section, eliminate having to walk in snow or mud, and, because of the steam tracer lines, any snow falling on the surface will be melted, thus keeping the walk clean and dry.

Drum on Flare Prevents Dangerous Oil Pollution

Here is a unique idea which can prevent oil pollution around lease gas flares. On many occasions, separator dump valves have hung up causing production to flow through the separator gas line and out the flare riser onto the ground. Loss of oil in this manner results in both a fire hazard and a threat to livestock, as well as loss of revenue.

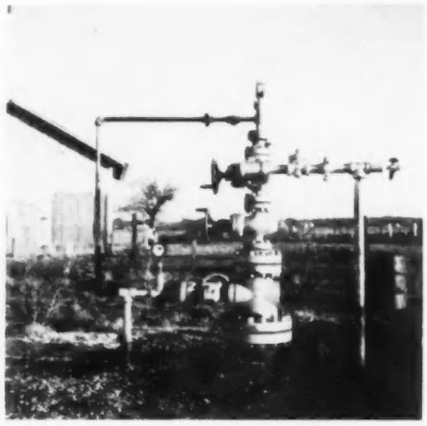
This West Texas producer solved the problem as shown. A discarded 55-gallon chemical drum is side mounted on the flare riser. An additional riser is connected to the bottom of the drum. All lines consist of 4-inch pipe.

If and when oil is carried over into the gas line, it collects in the drum and drains down the secondary riser which is tied into a line leading to the tank battery fire wall. Oil lost is collected inside the fire wall where it can be picked up by the battery pump and returned to storage once the faulty dump valve has been repaired.

Save Doghouse Space With Dual Seat - Storage Box

Space in a change shack or doghouse is usually considered a premium, and usually it is necessary to combine the use of the space for one of several different ideas.

A Gulf Coast drilling contractor, in order to conserve space, has built storage boxes on one side of the doghouse for spare parts. The sheet metal lid is hinged at the back so that when it is not necessary to have the storage box open, this lid forms a seat for the crew to use when changing clothes.



Install 'Rocking' Line On Gas Lift Well

This South Louisiana operator has installed a 1-inch "rocking" line on all gas lift wells in his area. Occasionally wells which are produced by gas lift will not perform properly.

This may be due to downhole gas lift valves sticking either in the open or closed position, or perhaps the well will not "work down" to the operating valve. In such cases, it is common practice to tie high-pressure gas into the tubing and "rock" the well by alternately pressuring and bleeding down the tubing and casing.

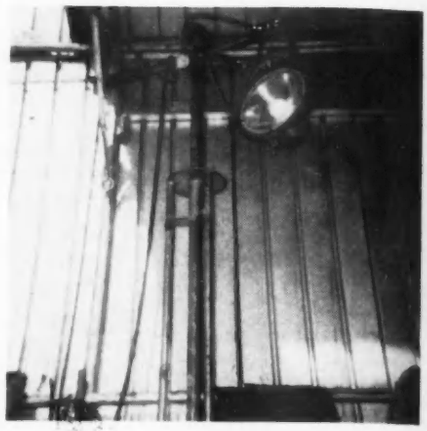
A permanent hook up for "rocking" a gas lift well has been installed as shown in the photograph. Only 1-inch connections and a 1-inch valve are required to tie the high-pressure gas line into the tubing.

Mount Rig Light At Adjustable Height

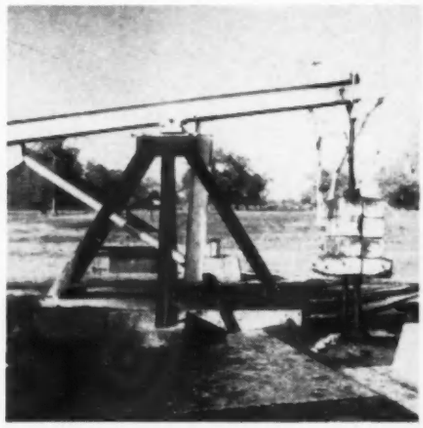
Good light around a rig is a must and any means of improvement will certainly result in more efficiency from the crew members.

The supports for this rig light are built in the shape of a T and lights can be hung from either or both arms of the T.

The T and and the rod top portion of the support are made of 1-inch pipe. This pipe then slides or telescopes into a base of slightly larger diameter pipe. The base is supported by tripod legs. These legs are made of ½-inch tubular stock.



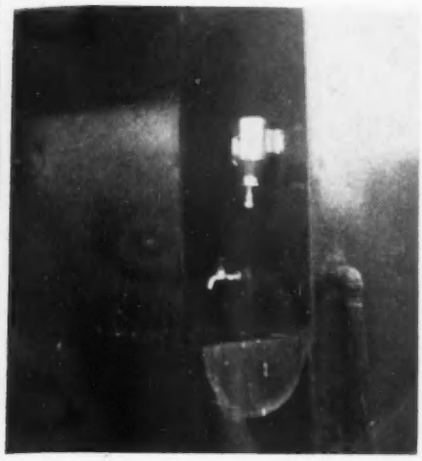
Holes are drilled in both the base pipe and the T-support pipe so that the T-support can be lowered or raised to a desired level and secured in place with a pin.



Use Concrete Blocks For Counter Balance

This Gulf Coast operator has found an excellent use for discarded concrete blocks. As illustrated, these blocks have been strung on a wire rope sling, and hung from the walking beam of the pumping unit where they provide counter balance for the rod string.

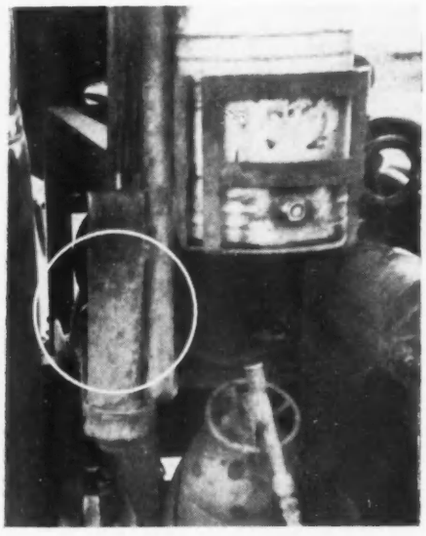
A piece of 2-inch pipe which is greased thoroughly is set in the ground below the rear end of the walking beam and passes through a circular hole in the blocks. This pipe serves as a guide for the blocks and keeps them from swinging laterally. If a change in counterbalance is indicated, the blocks may be added or subtracted from the load simply by disengaging the wire rope sling from the walking beam.



Convert Used Oil Drum Into Rig Wash Basin

A wash basin has been fabricated from a used oil drum so that the crews may wash up before leaving the rig. The drum has been cut leaving a trough like basin. The drum is then welded to the side of the change house and supported by two 3-inch angle irons.

One end is welded to the basin as shown while the other is welded to the wall. Water is then piped into the basin and washing facilities are now available for the crew members.



Use Scrap Pipe to Build Paper Cup Receptacle

A length of 3-inch pipe welded to the bed or headache frame of lease vehicles holds a day's accumulation of used paper drinking cups.

The bottom of the pipe is closed by a cap, which is unscrewed to empty the receptacle. The use of the receptacle prevents littering of the location.

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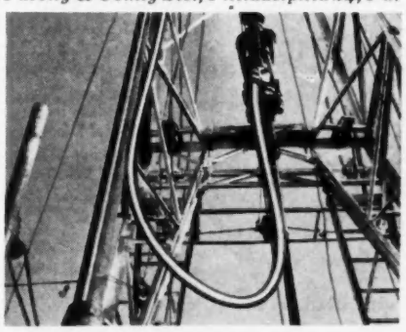

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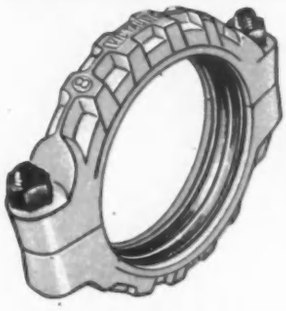

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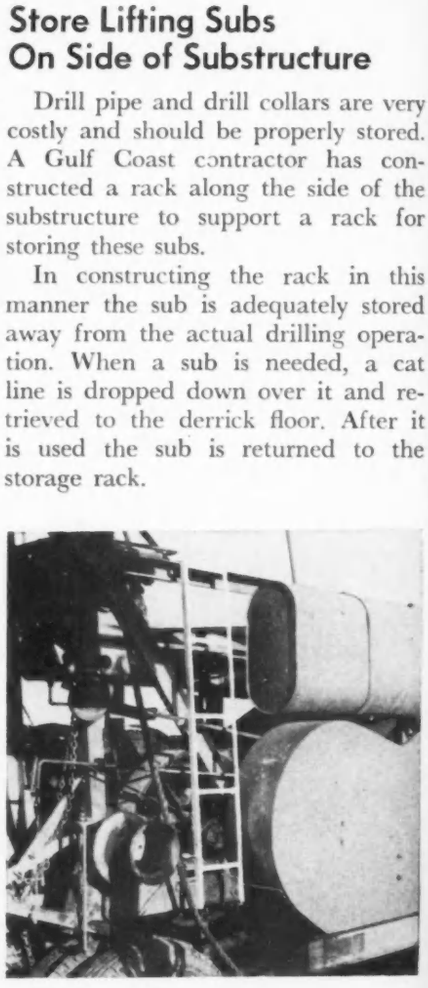
Store Lifting Subs On Side of Substructure

Drill pipe and drill collars are very costly and should be properly stored. A Gulf Coast contractor has constructed a rack along the side of the substructure to support a rack for storing these subs.

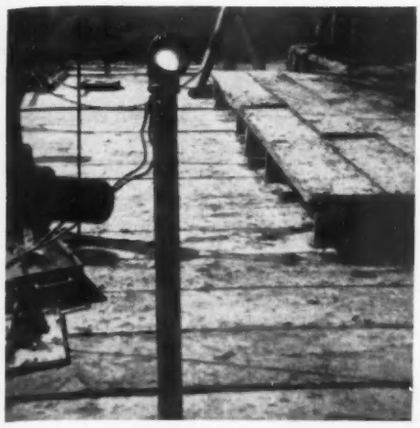
In constructing the rack in this manner the sub is adequately stored away from the actual drilling operation. When a sub is needed, a cat line is dropped down over it and retrieved to the derrick floor. After it is used the sub is returned to the storage rack.



Ladder on Spudder Provides Safety, Speedy Entry to Unit

A ladder welded on a spudder provides easy access to the machine for greasing and maintenance. In addition to speeding entry on the unit, it prevents the crew from having to step on the throttle and reverse rods as they climb.

The ladder shown came from the inside of an old oil tank, but could be made easily from 1-inch angle iron.



Light Bulb Placed in Pipe Protected from Breakage

A Gulf Coast contractor has built a work light using a length of pipe, an elbow, a light bulb and a socket. The light can be used for general lighting around the rig or else it can be used for close up work. Because of its design, it is protected from normal breakage.

The light socket is mounted in a hole drilled in the curved portion of the elbow. The elbow is made up loosely on the pipe so that it may be turned in any direction. The pipe is 2½-inches OD and is welded to a base plate. The plate is then securely fastened to the floor and is considered a fixed member of the rig.

'Stripe' Cattle Guards For More Night Safety

This Gulf Coast operator has found that it is much easier to spot cattle guards leading into leases at night when they are "striped" with yellow and black paint. This prevents truck drivers delivering pipe, heavy equipment, etc., from accidently striking the guard and also enables pumpers on the night tour to easily spot all lease entrances.

Congrats and $25 to WM. L. CAIN, Production Dept., Phillips Petroleum Co., Bartlesville, Okla.

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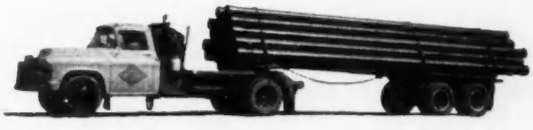

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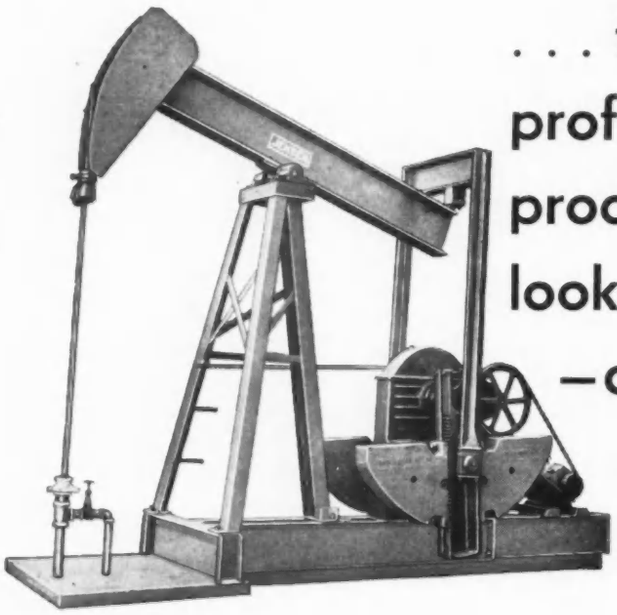

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A sheet of building tin was bent into a semi-cylinder and hung by wires under a steam line. Large quantities of cuttings are quickly and easily dried. The trough may be easily cleaned by either washing it out with water or else just turning it over. After the trough is used, it may be unfastened from the steam line and stored until further use.

Pipe Guide Improves Rigidity of Rig Piping

To improve the rigidity of piping around a rig, a Gulf Coast contractor uses a pipe guide securely fastened to a rigid member. This can either be a larger pipe as shown, as a component part of the rig.

The guide is made of a scrap of metal usually available around a rig. A hole is cut in the metal approximately the size of the guided pipe. The guide is then welded to a fixed member.

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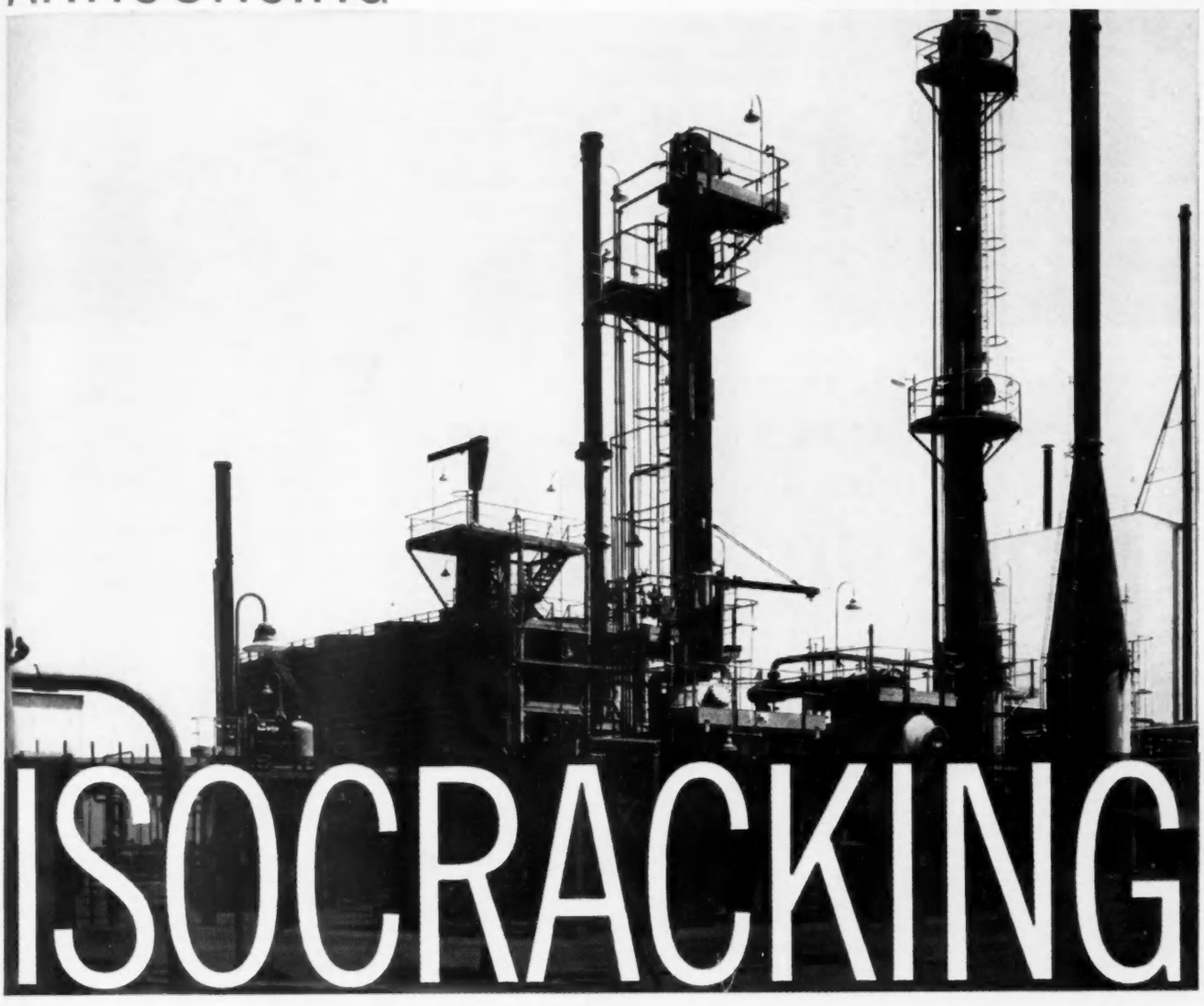

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*Proprietary Name

Derrick Leg Toe-Holds Aid Workers Climbing Rig

Normally, the derrick man has to be half "monkey" in order to reach the derrick ladder from the rig floor.

However, a West Texas toolpusher has minimized the dangerous aspects that this situation could present. He has welded short pieces of bar stock to the derrick leg to form a toe hold.

This has aided the crew members to climb up or down the derrick via the derrick leg without danger of slipping.

Gas Line Riser Made Stable with Pipe Braces

A normally unstable down-commer gas line from the top of a 27½-foot heater-treater can be braced easily in the manner shown in the photo. The two horizontal braces are constructed of 2-inch pipe and are welded on one end to the outside of the treater shell.

At the apex of the V-brace, a curved section of 6-inch pipe has been installed in the manner shown. A second section of 6-inch pipe comprises the remainder of the gas line guide and is bolted to the first section. When the bolts are removed, the down-commer line is free and can be removed, if necessary.

Safety Pin on Lube Barrel Prevents Serious Injury

There is quite often the possibilities of serious injury resulting if a barrel should roll or fall from its structural support. Consequently, to eliminate this possibility, an L-shaped pin was welded to the front leg of the holder. This enables the barrel to slide forward on the barrel holder until it comes into contact with the pin. This pin is made in a L-shaped form from ½-inch rolled stock and is welded in the position shown.

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A WORLD OIL SPECIAL REPORT

The cost-price SQUEEZE ...and what can be done about it

Excessive productive capacity . . . oversupply . . . rising costs . . .

These are just a few of the oil and gas industry's current economic problems. However, the industry is well aware of these "profit stealers" and is doing something about them.

One example of efforts to improve the industry's profit picture started early in 1957 with company acquisitions, followed by a wave of mergers. Then, recently came announcements of major reorganization plans by Humble Oil and Refining Company, Gulf Oil Corporation, Mobil Oil Company, and others.

In addition to these efforts, oil industry leaders are stressing the need to step up technological achievements, both in methods and equipment.

As a contribution to the oil and gas industry's effort to improve its cost-price relationships, WORLD OIL has prepared the following special report, including:

1. **A condensation of five major economic studies.**
2. **Reasons for the cost-price squeeze.**
3. **Technological developments that could help cut costs.**
4. **How one company determines cost.**

Those who have other data on the cost-price squeeze, and/or suggestions as to how industry profits can be improved, write WORLD OIL, P. O. Box 2608, Houston, Texas.

A WORLD OIL SPECIAL REPORT

What's happening to oil industry dollars?

Five oil industry cost studies have been completed in the past 12 months. They reveal the following cost-price trends:

The average value of one million Btu's of crude oil and natural gas at the wellhead has increased only 4 percent since 1948, while the increase in average cost of exploration, development and production has risen approximately 62 percent—and there is no evidence of an decline in this trend through 1959.

o o o

Average cost per well was $46,300 in 1954, $46,500 in 1955 and $50,200 in 1956. Average cost per foot drilled for all wells was $12.56 in 1954, $12.94 in 1955 and $13.64 in 1956.

o o o

Following present trends, drilling costs could aver-average $16.39 per foot in 1960, $20.11 in 1965 and $24.38 in 1970—nearly 70 percent higher than 1957 costs.

o o o

If present margins between average cost per barrel of replacement crude oil are used, the average price of crude oil would be $3.30 in 1960, $4.35 in 1965 and $6.50 in 1970.

o o o

Prices charged by drilling contractors have decreased every year since 1952—from $5.85 per foot to $4.50.

o o o

There was one point of agreement in virtually all of the studies—the oil industry, with all of its great technical progress during the past century, has yet to create an accurate conclusive method of determining its operating costs.

The most urgent needs include an accurate method to separate the finding, developing and producing costs of oil and gas wells—more accurate and complete cost-by-depth reports from specific areas—more specific information on service wells, including a uniform, industry wide distinction between service wells and dry holes, also between gas, condensate and oil wells—and a method to determine the net effect of lower contract drilling prices and greater well depths on total per well costs.

The need for more reliable oil industry statistics was aptly described by the Independent Petroleum Association of America's Cost Study Committee in concluding is report to the membership last may:

"It should be apparent that these (cost study) findings fail to satisfy the urgent need for comprehensive cost information on all phases of the production segment of the petroleum industry. The urgency of this need stems from the contribution that reliable, comprehensive cost information can make to the intelligent planning by the industry and the formulation of public policies affecting the industry, e.g., policies relating to taxation, conservation, foreign trade, etc.

"Inasmuch as there is currently a serious lack of adequate industry cost data and since reliable cost information is of vital importance to the industry and to governmental agencies, your committee recommends the adoption of the following resolution . . ."

That resolution was to appoint a committee to find ways and means of developing more complete, factual petroleum cost data.

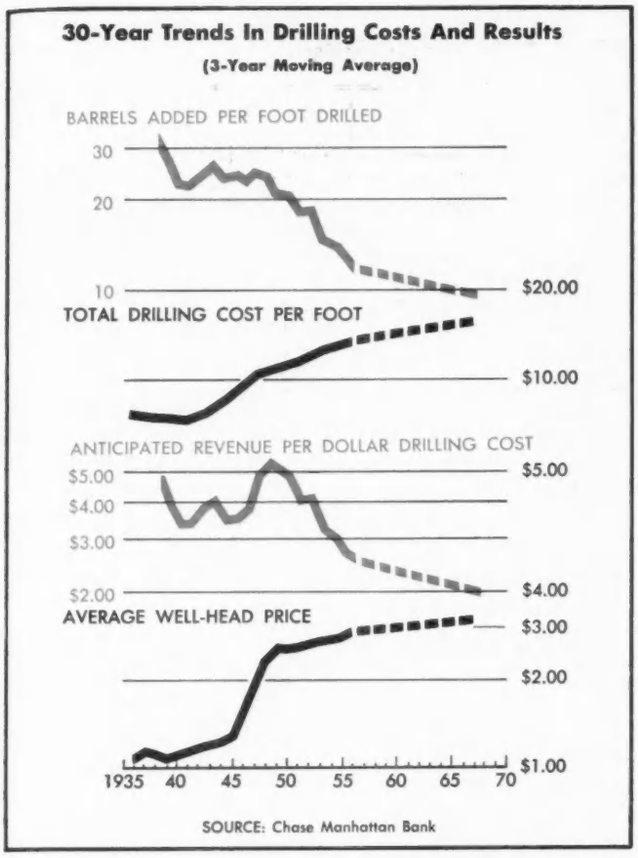
With these qualifications in mind, following are condensations of the five major economic studies.

CHASE MANHATTAN BANK

According to recent Chase Manhattan studies the oil industry must drill approximately 670,000 wells and 3 billion feet of hole between 1957 and 1967. By 1967, annual drilling activity should approach 75,000 wells and 350 million feet of hole.

These projections include such factors as the need to increase production to meet demand growth—and at the same time maintain a production-reserve ratio considered safe for defense purposes. Also included is the fact that the number of wells drilled annually during the postwar years have increased substantially. Yet, during several of these years additions to liquid hydrocarbon reserves did not increase proportionately.

For example, 33,798 wells were drilled in 1947, adding nearly 705 million barrels of crude oil and natural gas liquids to total reserves after meeting production needs. Ten years later 54,173 wells were drilled, resulting in a



net deficit of 349.2 million barrels of crude oil and natural gas liquids that had to be subtracted from total reserve at year's end.

Last year, although 8,754 more wells were drilled than in 1948, only 753 million barrels of liquid hydrocarbons were added to total reserves after meeting production needs—about one-third the total added a decade earlier.

These comparisons clearly indicate that the unit results of the drilling effort are declining. Among the various tests of exploratory results, barrels added per foot drilled is one of the best. And this measurement has been declining steadily as indicated on the accompanying chart.

In contrast with the decline of barrels added per foot drilled is the rising level of drilling costs per foot. When these opposing trends are related to the average wellhead price of crude oil, there is indicated a shrinkage of anticipated gross dollar of drilling costs.

Pointed up is the fact that the economic limits of drilling costs per barrel may be fast approaching. It is becoming increasingly apparent that the industry must upgrade its exploratory effort and reduce drilling costs if it is to operate within the current price framework.

HANER REPORT ON PROJECTED DRILLING COSTS

The cost of exploration and development on a per foot basis as reported by the American Association of Oil Well Drilling Contractors shows the combined effects of expense from labor, equipment, materials and depletion. After being constant for almost a decade, they began to rise after the war and reached a level in 1957 that was 60 percent higher than earlier figures.

To project this into the future, Fred T. Haner, Regional Industries Development Corporation, used a multiple correlation with three series:

1. Average depth.
2. Average hourly rate for oil and gas production workers.
3. The wholesale price index for non-agricultural items.

The combination of these three showed a relationship that was 99.3 percent valid over the 23 years of experience. The result of combining these three projctions shows costs reaching $24.38 per foot by 1970, up 70 percent from 1957.

Projected costs. In the future, as now, a company's income will control the volume of exploration and development. If income increases at the same rate as costs, the industry stands an excellent chance of progressing economically.

However, experience has shown that the oil industry has not been able to raise prices relative to cost as other industries have done. Imports of crude oil and refined products are available with price structures that give considerable flexibility to the prices that could be charged and yet be profitable.

If mandatory controls on imports were set at a figure near the present levels (700 million barrels per year), it would seem logical that the average price of crude would rise proportionately with the cost of replacing each barrel.

If present margins between the average cost per barrel of replacement and the price per barrel are used, the average price of crude oil would be $3.30 in 1960, $4.35 in 1965, and $6.40 in 1970.

It is much more likely that, as crude oil becomes more difficult to find and imports are limited, prices would rise in proportion to discovery rates and increases in other costs. This could be estimated at $3.50 in 1960, $5.05 in 1965, and $8.15 in 1970.

Most could envision government intervention before an increase of this magnitude takes place.

With the cost of replacing each barrel of oil narrowing the margin of profit, it can be concluded that drilling activity in this country will follow the trend indicated by the Index of Financial Drilling (see Page 96) more closely than in the past when the margin was adequate.

JOINT ASSOCIATION SURVEY

A special study on drilling costs—the second ever compiled on an industry-wide basis—was completed last May (See World Oil July, Page 120).

Prepared by the American Petroleum Institute, the Independent Petroleum Association of America and the Mid-Continent Oil and Gas Association, the current study is based on 1955 and 1956 data—the most recent available. The project was undertaken to provide authoritative information on the cost of drilling and equipping oil and gas wells and dry holes in the United States. The first study was published in1955, based on 1953 data.

Drilling cost trends outlined in the later report include only the actual expense of drilling and equipping the wells through the christmas tree at the wellhead, without any allocation for administrative overhead, production equipment and predrilling expenditures.

How Cost-Price Trends Will Affect Drilling Activity

	PRODUCTION REVENUE PER BARREL				Margin In[3] Constant Dollars	Index of Drilling[4] Activity
	Oil-Price at The Wellhead +	Gas-Price Equivalent[1]	— Cost per Bbl. of Replacement[2] =	Margin per Bbl.		
1935....	$ .97	$ .11	$ .45	$ .69	$1.13	60
	1.09	.11	.36	.84	1.48	79
	1.10	.10	.22	1.06	1.74	93
	1.13	.09	.22	1.00	1.71	91
	1.02	.10	.27	.85	1.46	78
1940....	1.02	.09	.38	.73	1.23	65
	1.14	.10	.37	.87	1.37	73
	1.19	.11	.27	1.03	1.51	80
	1.20	.12	.33	.99	1.43	76
	1.21	.11	.34	.98	1.39	74
1945....	1.22	.11	.40	.93	1.30	69
	1.41	.12	.33	1.20	1.53	81
	1.93	.15	.43	1.65	1.73	92
	2.60	.17	.35	2.42	2.34	124
	2.54	.19	.42	2.31	2.28	121
1950....	2.51	.21	.53	2.19	2.09	111
	2.53	.24	.40	2.37	2.04	109
	2.53	.27	.68	2.12	1.07	99
	2.68	.33	.61	2.40	2.11	112
	2.78	.38	.90	2.26	1.97	105
1955....	2.77	.39	.89	2.27	1.94	103
	2.77	.42	.84	2.35	1.92	102
1957....	3.10	.46	1.20	2.36	1.88	100
1960....	3.30	.57	1.40	2.46	1.83	97
1965....	3.80	.83	2.45	2.19	1.44	77
1970....	4.40	1.07	4.50	.97	.58	31

[1] Natural gas/crude oil production ratio x price per Mcf.
[2] Pertains only to exploration and development expense. Computed by dividing cost per foot by barrels discovered per foot.
[3] Computed through use of the Wholesale Price Index, Non-agricultural items.
[4] 1957 = 100.
Source: Fred T. Haner.

As long as incentive is adequate, drilling activity will increase regardless of fluctuations in the index. However, when average cost per barrel of replacement narrows the margin provided by revenues from both natural gas and crude oil, it is possible to anticipate a decline in drilling activity. This is a major factor in today's depressed drilling situation.

Per well cost increase. The average cost per well was $46,500 in 1955, and $50,200 in 1956. The average cost per foot increased from $11.55 in 1955 to $12.35 in 1956.

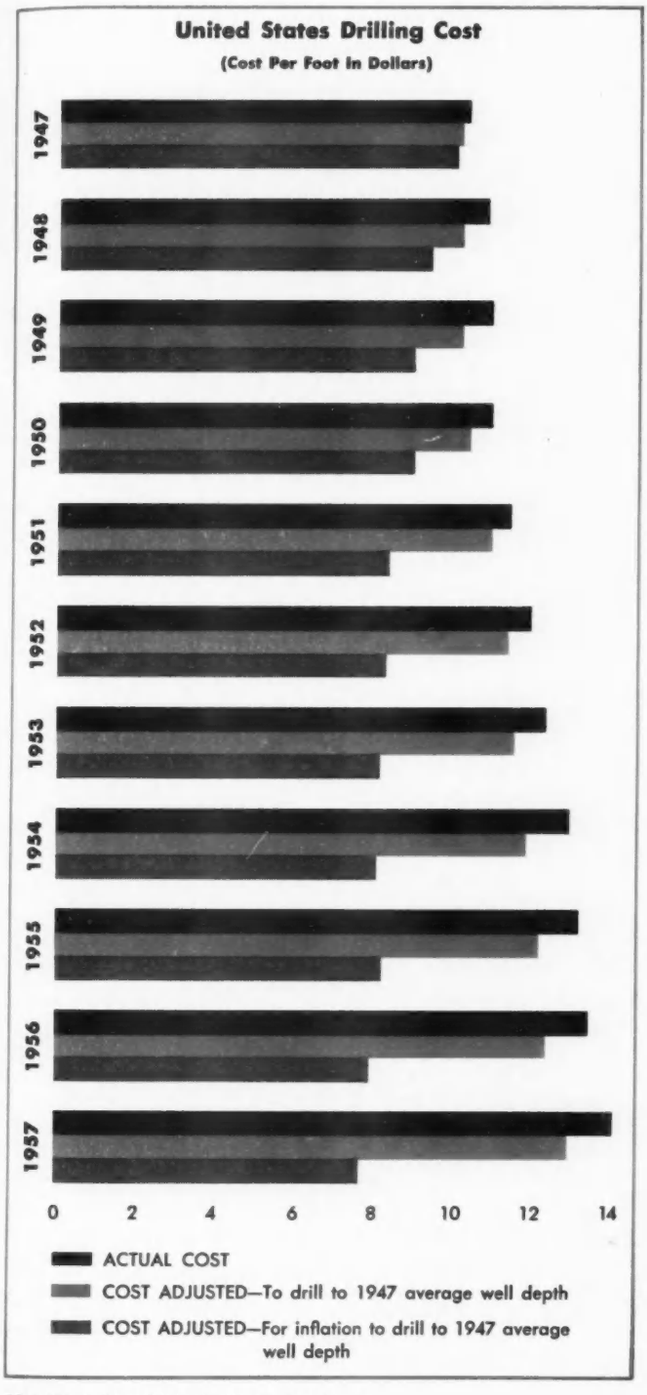
The U.S. Bureau of the Census reported 1954 costs as follows: per well, $46,300; per foot, $11.03. The rise in cost is due largely to increased drilling in the offshore areas of Texas and Louisiana, drilling of more extremely deep wells, and to rising costs of labor and materials.

The cost per foot increased from the Census reported average of all wells of $12.56 in 1954, to $12.94 in 1955, and to $13.64 in 1956. The average cost of productive wells drilled was $52,300 in 1954, $51,900 in 1955, and $55,600 in 1956.

Officials of the three associations conducting the study emphasize that wage rates and materials prices have continued to rise to such an extent that current drilling costs per foot would doubtless average more than reported for 1956.

Other costs. The industry also spent large sums drilling dry holes. In 1955 outlays for 20,746 dry holes were $774 million and in 1956 the total was $909 million for 21,845 dry holes. Compared with the 1954 census average of $34,500 each, the cost per dry hole increased to $37,300 in 1955, and again to $41,600 in 1956.

The study also shows how costs skyrocket as the depth of wells increases. For example, in 1956, the average cost of 14,006 wells ranging in depth from 2,501 to 3,750 feet



SOURCES: A.P.I., I.P.A.A., Mid-Continent Oil and Gas Association Joint Survey; WORLD OIL.

was about $26,500 while the average cost of the 150 wells over 15,000 feet deep (averaging 5¼ times as deep) was $761,700 or 29 times as expensive.

Also significant is the high cost of drilling wells in offshore areas. For example, the average cost per offshore well in 1956 was $415,000, compared with an average cost of $47,100 for wells drilled in other areas.

AMERICAN ASSOCIATION OF OILWELL DRILLING CONTRACTORS

Recent cost studies conducted by the AAODC reveal the following cost-price trends during the 14-year period since World War II:

- Total new wells completed increased from 26,649 in 1945 to 48,312 in 1958—up 81.3 percent.
- Average depth per well increased from 3,489 feet in 1945 to 4,031 in 1958—up 15.5 prcent.
- Average total cost per foot drilled increased from $9.00 in 1945 to $13.25 in 1958—up 47 percent.
- *Drilling prices charged by contractors decreased from $5 per foot in 1945 to $4.50 in 1958—down 10 percent.*

In fact, last year the average total cost per foot drilled decreased for the first time since 1941—from $13.60 to $13.35 per foot. (See table on Page 98.)

According to the AAODC report, the slight downward trend in costs during 1958 was the result of four factors:

1. A smaller percentage of wildcat wells were drilled.
2. Slight modifications in some casing programs.
3. A lesser average well depth.
4. An improved rate of penetration.

The fact that drilling contractor prices have decreased every year since 1952 while costs have shot upward is a remarkable achievement in itself. Operating closer to the belt, plus development of more efficient drilling methods and equipment have played important roles in holding contractor prices down.

However, according to AAODC Executive Vice President Warren Baker, two factors may soon have a marked effect on contractor prices:

1. Need to make large scale purchases of new equipment to maintain increased penetration rates.
2. Need to improve living conditions and wages to attract skilled rig crews.

INDEPENDENT PETROLEUM ASSOCIATION OF AMERICA

Last May the Cost Study Committee of the Independent Petroleum Association of America published its most recent report on the cost of finding, developing and producing liquid hydrocarbons and natural gas in the United States. Following are highlights from that report:

The cost of finding and developing one million Btu's of oil and gas rose from 6.71 cents in 1948 to 12.31 cents in 1955, an increase of 85 percent.

As indicated in the table on Page 98, finding costs increased more rapidly than development costs. However, the committee has not yet been able to separate these elements using information currently available.

The cost of producing one million Btu's of oil and gas increased from 6.64 cents in 1948 to 7.28 cents in 1955, an increase of approximately 10 percent. A weighted average shows that the combined cost of finding, developing and producing one million Btu's of oil and gas was 62 percent higher in 1955 than in 1948.

Why activity is down. The committee believes that the recent decline in exploration and development activity, and the corresponding decline in additions to reserves through new discoveries are evidence of the effect of increasing costs on producers' margins.

Historically, there has been a close correlation between exploration and drilling activity and the cash flow from operations in the oil industry. But, the gross realization from the sale of crude oil and natural gas must be sufficient to cover all economic costs of finding, developing

Drilling Costs Are Going Up . . . Contractor Prices Are Going Down

YEAR	UNITED STATES DRILLING COST-PRICE TRENDS			
	Total New Wells Completed	Average Depth Per Well	Average Contract Cost Per Foot	Average Total Cost Per Foot
1935	24,851	2,760	5.00	8.00
1936	28,962	2,797	4.75	7.75
1937	35,213	2,985	4.50	7.50
1938	29,127	3,110	4.25	7.50
1939	28,012	3,053	4.25	7.50
1940	31,149	3,088	4.00	7.50
1941	32,510	3,056	4.25	7.25
1942	21,990	3,088	4.00	7.50
1943	20,349	3,046	4.50	8.00
1944	25,786	3,272	4.75	8.25
1945	26,649	3,489	5.00	9.00
1946	30,230	3,345	5.00	9.50
1947	33,147	3,404	5.00	10.25
1948	39,477	3,463	4.75	10.75
1949	38,962	3,558	4.75	10.75
1950	43,204	3,689	5.00	11.00
1951	44,196	3,869	5.50	11.50
1952	45,879	4,060	5.85	12.00
1953	49,279	4,016	5.60	12.50
1954	53,650	4,025	5.10	12.75
1955	56,850	4,044	4.90	13.25
1956	58,271	4,022	4.75	13.50
*1957	53,472	4,103	4.60	13.60
**1958	48,312	4,031	4.50	13.25

* Revised. ** Estimated.
Source: American Association of Oil Well Drilling Contractors.

Finding-Development Costs Increase 83.5 Percent in 7 Years

YEAR	Expenditures for Exploration and Development[1] ($000)	Expenditures for Production Oil and Gas[1] ($000)	Exploration and Development Expenditures per Million Btu's Gross Additions To Oil and Gas Reserves[2]	Production Expenditures per Million Btu's of Oil and Gas Produced[3]
1948	$2,582,954	$1,313,519	$0.0671	$0.0664
1951	3,547,170	1,613,273	0.0782	0.0673
1953	4,296,365	1,844,497	0.0987	0.0717
1955	5,127,465	2,021,334	0.1231	0.0728

SOURCES: [1] C. C. Anderson, "Petroleum and Natural Gas in the United States—Relation of Economic and Technologic Trends, "Canadian Sectional Meeting, World Power Conference, September, 1958. [2] Computed from reserve data of American Petroleum Institute and American Gas Association. [3] Computed from production data of U.S. Bureau of Mines.

and producing these resources, and in addition must provide for all taxes and a net profit after taxes sufficient to attract the necessary capital to finance the future expansion of this hazardous industry.

The nature of the squeeze on the producers' margin is readily apparent from the fact that the average value of 1 million Btu's of crude oil and natural gas at the wellhead has increased only 4 percent since 1948, while the increase in average cost of exploration, development and production between 1948 and 1955 was approximately 62 percent—and there is no evidence of a downward trend through 1959.

Reasons for the cost-price squeeze

THE COST OF CRUDE oil exploration and development for 32 oil companies has increased rapidly during the past 10 years—from an average of $1.38 per barrel produced during 1949-1953 to $1.83 per barrel during 1954-1958. Thus, average costs increased 32.6 percent during the last half of the past decade.

The same two five-year periods show per barrel crude price averages of $2.56 and $2.89 respectively, according to U.S. Bureau of Mines reports—an increase of only 12.9 percent. Although crude prices improved after the Suez Crisis, they started a downward adjustment during 1958 that is still continuing.

Under ideal conditions crude prices would have kept pace with rising costs during the above two periods. However, the situation is far from ideal in the oil industry—for three reasons:

1. Intense competition from crude oil.

2. Existence of ample domestic crude oil productive capacity.

3. Increasing competition faced by distillate and residual fuels from alternate types of energy.

Imports and prices. Studies by Continental Oil Company economics group indicate that since 1952 the ratio of reserves to production in the Free World has jumped abruptly from a long-term historical level of about 20 to 1 to reserves in excess of 40 to 1.

Clearly, the Free World has a far greater availability of crude oil in relation to demand than at any time in the past 40 years or more. As long as this abundance of supply exists, prices in Free World markets will be under constant downward pressure.

This pressure will be particularly keen in the United States because of the cost advantages of foreign crude. It is generally recognized that Middle Eastern crudes can be delivered for refining on the East Coast at least 50 cents per barrel below the prices for comparable West Texas crudes.

Excess productive capacity. Estimates of the National Petroleum Council and Independent Producers' Association of America both indicate that the domestic producing industry operated at well below 80 percent of capacity during 1957 and 1958. At the end of 1958, production was estimated at about 70 percent of capacity, and probably not more than 55 percent in Texas.

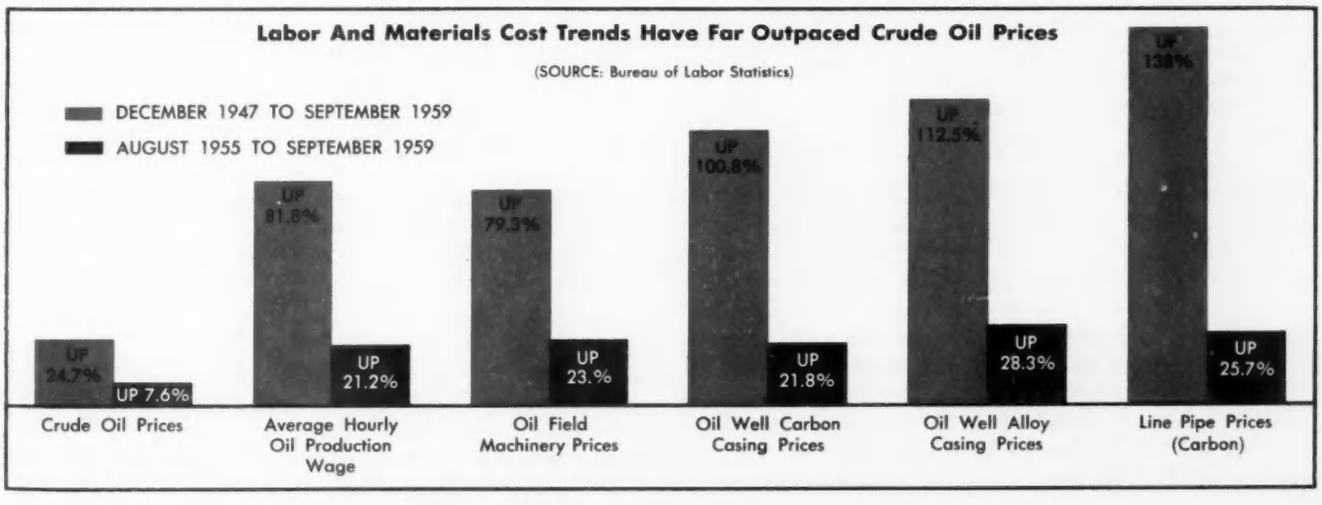
The disparity in the growth of domestic consumption and domestic productive capacity is revealed in the following figures:

Each year from 1950 through 1956, domestic requirements of crude oil increased about 365,000 barrels daily. Approximately 75,000 barrels of this average annual gain was met by increases in imports of foreign oil.

The net gain in consumption of domestic crude oil was thus only 290,000 barrels daily during the above period. However, according to NPC studies, daily domestic productive capacity increased 523,000 barrels each year.

Two conclusions may be drawn from these figures:

First, the difference between the average annual increase in consumption of domestic crude oil and in domes-



tic capacity, amounting to an annual average of 233,000 barrels a day, is one measure of the extent to which the U.S. oil industry's ability to produce oil has outstripped current needs.

Second, it is apparent that even if imports of foreign oil had not increased at all, the growth in productive capacity during 1950-1956 still would have exceeded the nation's annual requirements by 158,000 barrels daily.

Competing fuels. A third circumstance tending to restrain crude oil price advances is the increasing competition certain petroleum end products are facing from other fuels. This is particularly true in the case of distillates and residual fuel. Natural gas is making large inroads in the domestic heating oil market.

In the industrial and commercial markets, coal is offering increasing competition to both distillate and residual fuel oils. Competition in these markets is based almost entirely on price, except in situations where distillate has an advantage because of its greater convenience.

Under the pressure of necessity, the coal industry in recent years has been improving its technology. New mechanized extraction methods, underground gasification and pipe line transportation now are helping to make coal more competitive with oil.

WHY COSTS ARE INCREASING

Factors contributing to increased oil industry costs in recent years include:

1. Higher materials and labor costs.
2. Increased taxes.
3. Greater number of expensive deep well and marine operations.
4. More dry holes.
5. Increased total footage.
6. Less reserves per foot drilled.

Higher materials and labor costs. Based on the 1947-49 = 100 Bureau of Labor Statistics Index, oil field machinery and goods prices have increased from an index of 94.2 in December 1947 to 168.9 last August—up 79.3 percent in less than 12 years.

Within the past five years (1955-59), the index has increased 23 percent, from 137.5 to 168.9.

Wages for crude oil and natural gas production personnel have increased from $1.54 per hour in December 1947 to $2.80—up 81.8 percent during the 12-year period. In the past five years, wages have risen 21.2 percent, from $2.31 per hour to $2.80.

Motor vehicles, another important oil industry cost item, have increased 43.2 percent in cost since the 1947-49 period.

Increased taxes. The House Ways and Means Committee plans to start a thorough investigation of oil industry taxes, particularly the 27½ percent depletion provision, next month. Recommendations made by the Committee, if any, are expected to have a decided effect on any anti-depletion efforts made during the next session of Congress.

It is interesting to note that oil industry federal, state and local taxes have quadrupled since 1942, increasing from $1.6 billion annually to $6.9 billion last year. Taxes paid by the oil industry in 1958 accounted for about 70 percent of all U.S. taxes, including 25 percent of all state revenues—while accounting for about 6 percent of the annual gross national product.

Gulf Oil Corporation's Executive Vice President R. O. Rhoades recently made the following observation of the industry's tax trends:

"In 1926, the average price per barrel of oil in the United States was $1.88. In 1957 the price per barrel was $3.09. Thus, the 27½ percent depletion base increased 64 percent.

"The corporate tax rate in 1926 was 13 percent, whereas in 1957 it was 52 percent, an increase of 300 percent. The cost of finding and producing oil has increased more than 500 percent since 1926.

"This simple calculation demonstrates that the percentage falls far short of being as equitable now as it was in 1926 when Congress said it was fair and equitable."

Greater number of expensive deep wells and marine operations. The effort to keep U.S. crude oil and gas reserves at least 10 years ahead of the steadily rising consumption rate has resulted in a 15.3 percent increase in average well depth since 1949.

According to the American Association of Oilwell Drilling Contractors, in the 10-year period (1949-58), average yearly depth per well increased from 3,558 to 4,103 feet.

Extensive offshore operations along the Texas and Louisiana coasts began in 1954 with 30 drilling units, increasing to more than 100 units from 1956 on.

One example of higher offshore costs: it has been estimated that profits from offshore wells will average about 11 percent less for gas-condensate and 18 percent less for crude oil than identical onshore wells.

More dry holes. Increased wildcatting resulted in the drilling of nearly twice as many wildcat wells last year than were drilled in 1947 (9,762 wells compared with 4,983).

Last year's effort resulted in 8,719 dry holes or 89.3 percent of total wildcats drilled—compared with the 20-year average (1937-57) of 88.1 percent. Also, 20 percent of all the exploratory and development wells drilled last year were wildcats, up considerably from 16 percent in 1947.

These statistics mean more money is being spent to produce nothing.

Increased total footage. Between 1947 and 1958, the number of oil and gas wells drilled annually increased 55 percent, from 31,084 wells to 48,331.

Due to greater well depths, total annual footage advanced far more rapidly, increasing 73.6 percent—from 112.8 million feet per year to 195.8 million feet.

Less reserves per foot drilled. An important factor in oil industry cost-revenue relationship is reserves added per foot drilled. Here is the trend picture in brief:

- In 1948 every foot of hole drilled resulted in finding 28 barrels of crude oil reserves. The reserve ratio decreased to 14 barrels per foot drilled in 1954 and 11 barrels in 1958.
- In 1948, 101,346 barrels of crude oil reserves were found for every new well drilled. The ratio declined to 55,875 barrels per well drilled in 1954 and 46,283 barrels in 1958.

How to save with applied technology

THE DOMESTIC PETROLEUM INDUSTRY is being squeezed between two powerful and opposing sets of economic forces: Steadily rising costs and downward pressures on prices arising from the abundance of crude oil in the Free World markets, coupled with low cost natural gas.

These opposing forces are making it increasingly difficult to earn a satisfactory return on new investments in domestic oil finding and developing activities. To combat these forces, the industry must move aggressively and courageously.

The first line of attack lies in an imaginative, vigorous program of cost reduction in all phases of operations. Among other things, the industry must find means of curtailing unnecessary development drilling, improving exploratory techniques, increasing oil recovery, and expanding aggregate expenditures on scientific research.

There is no precise information available on the overall composition of the domestic petroleum industry's costs. However, it is estimated that the total cost, including capital and expense items, is distributed as follows: Finding costs—35 percent; development costs—45 percent; lifting costs—20 percent.

In short, a tough job lies ahead for the oil industry. It will require the cooperative effort of all segments of the industry. Getting everyone to recognize the seriousness of the task ahead and to act accordingly will not be easy.

However, in the words of Continental Oil Company President L. F. McCollum, "The challenge to reduce the cost of domestic oil is probably as great a task as we have ever faced. The will and the means to meet the challenge must be found—and find it we will!"

As a service to the oil industry, WORLD OIL has contacted top oil company, industry association and government sources[1] to obtain their ideas as to the ways in which applied technology can help cut industry costs. Their suggestions cover the following seven areas of industry operations:

- Sizing of lease and well equipment
- Lease and well operations
- Remedial well work
- Recovery projects
- Wellspacing
- Exploration methods and equipment
- Research.

REALISTIC SIZING

The trend toward lease and well equipment sized to do only the job it needs to do offers considerable hope for ailing oil industry economics. This includes rigs, bits and other equipment to permit full capitalization of small-diameter wells.

A second and equally important part of this trend is maximum use of each drilled hole through multiple completions.

Experience shows that production from the majority of domestic oil wells will not exceed 100 to 300 barrels per day. Realistic sizing of both well and surface producing facilities to handle these rates has opened up avenues to considerable savings in investment and operating costs.

Although the broad challenge of reducing well cost is now evident, some other developments of the past few years are important in determining future well size. Most wells must occasionally be reworked or serviced and this requirement must be considered in the selection of minimum well size.

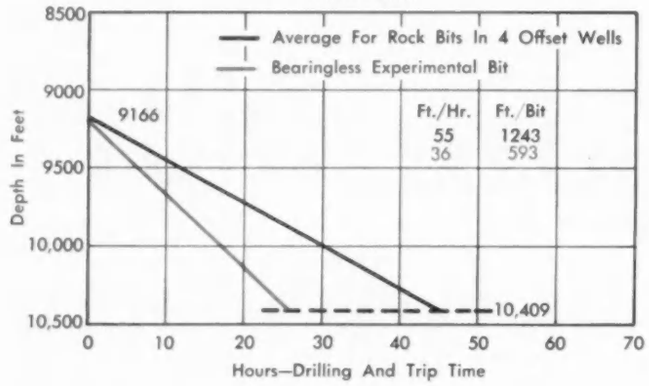
Reports before many industry forums have amply illustrated that through-tubing completion and workover systems using wireline tools or macaroni strings are not only practical, but also offer savings of 30 percent on land work and in excess of 85 percent on marine locations.

In the field of artificial lift, accompanying developments are reflected by the wireline retrievable and macaroni-type gas lift valves, the pump-out hydraulic pump, and, more recently, small, insert-type rod pumps for use in 1½-inch and 1¼-inch tubing on ½-inch or smaller rods. It is evident that many of the components required for realistically sized wells, with a saving of up to 70 percent in steel tonnage for a completely developed one-well lease, are available.

Thus, the first major challenge to mechanical technology is simply to develop the remaining tools and techniques needed to capitalize fully on the 2½-inch or smaller oil string of tomorrow. The developments should include:

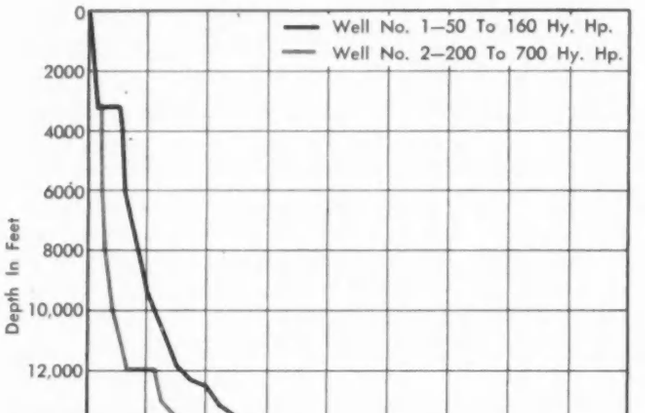
- A small bit with performance qualities that will permit generating chips at the same rate of today's conventionally sized bits. For those who feel the bearing problem is insurmountable, one operator using an experimental bearingless bit in a conventionally sized hole has obtained a 110 percent increase in bit footage and a 55

Experimental Bearingless Bit Versus Conventional Rock Bits



One operator using an experimental bearingless bit in a conventionally sized hole has obtained a 110-percent increase in bit footage and a 55-percent increase in penetration rate.

Effect Of Hydraulic Horsepower On Drilling Rate



By increasing hydraulic horsepower on well No. 2 (16,000 feet), total drilling time was reduced 57½ percent.

percent increase in penetration rate. The bearingless bit will present no problem in scaling down.

• A drilling rig modified to capitalize on the advantages of small-hole drilling. Also needed is a hydraulic system, including pumps designed to deliver reduced volumes at higher pressures. An accompanying development will be high-strength, lightweight drill pipe tailored to fit the hydraulic and depth requirements of this rig.

The magnitude of the potential saving here has been demonstrated on one 8,500-foot well where total cost for all operations was reduced about 50 percent, to $18,000.

• A formation evaluation system which will provide continuous recording of formation characteristics and fluid content as the well is drilled. Entirely adequate samples of formation fluid have been obtained utilizing a wireline tester element, in connection with a special drill collar which carries the tester-packer during routine drilling operations.

Total elapsed time for these drillstem tests, which require no trips, was less than two hours for tests at 7,000 feet.

• A drilling fluid that will permit drilling rates attainable with water or air and still retain such necessary features of present drilling muds as weight to control formation pressures, sealing properties to prevent hole sloughing, and characteristics that will not damage formation productivity.

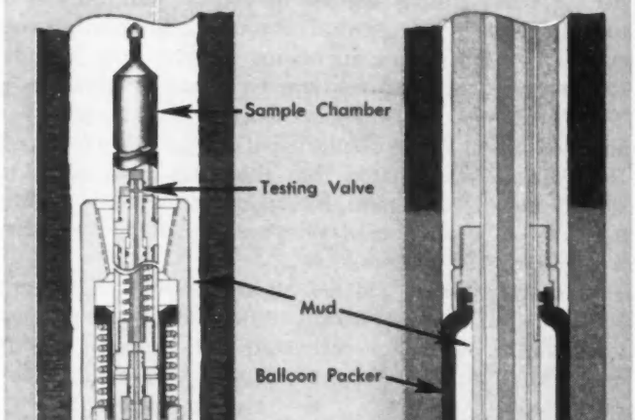
Savings of up to $28 per foot have been realized on offshore wells through application of this principle.

• Improvements in tubingless and multiple completions. The increased cost of finding and developing domestic production—coupled with improvements of equipment and techniques—has speeded up the use of dual, triple and quadruple completions.

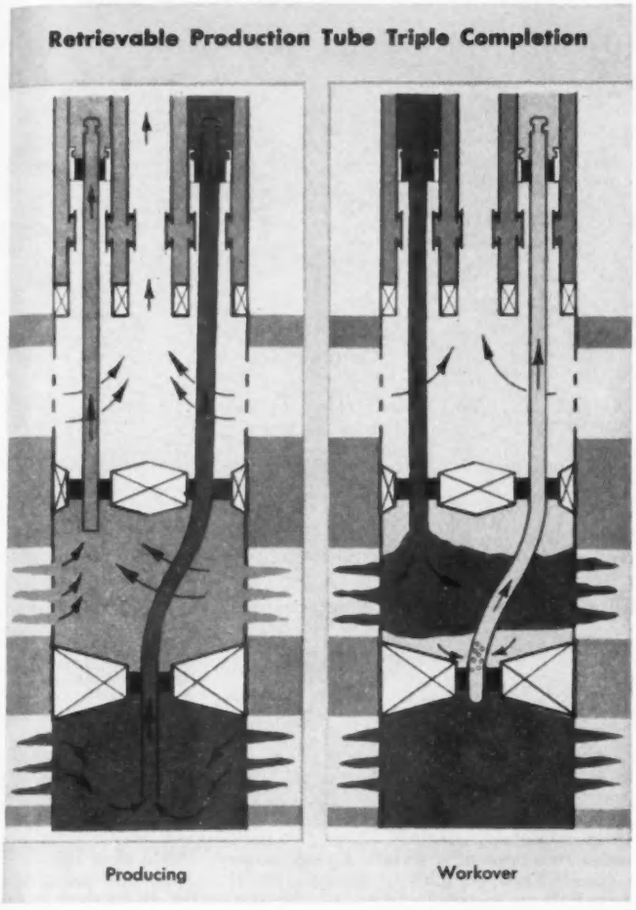
The tubingless completion technique is ideally suited for multiple completions. Conventional tubing used as casing side by side in the same well bore offers versatility in completion and workover operations, as well as important savings.

Average savings on single tubingless well completions figure out at about 20 percent of the cost of conventional wells. The bulk of these cost reductions can be traced to the use of less steel, but savings also reflect improvements in other well completion practices that could be applied to ordinary wells.

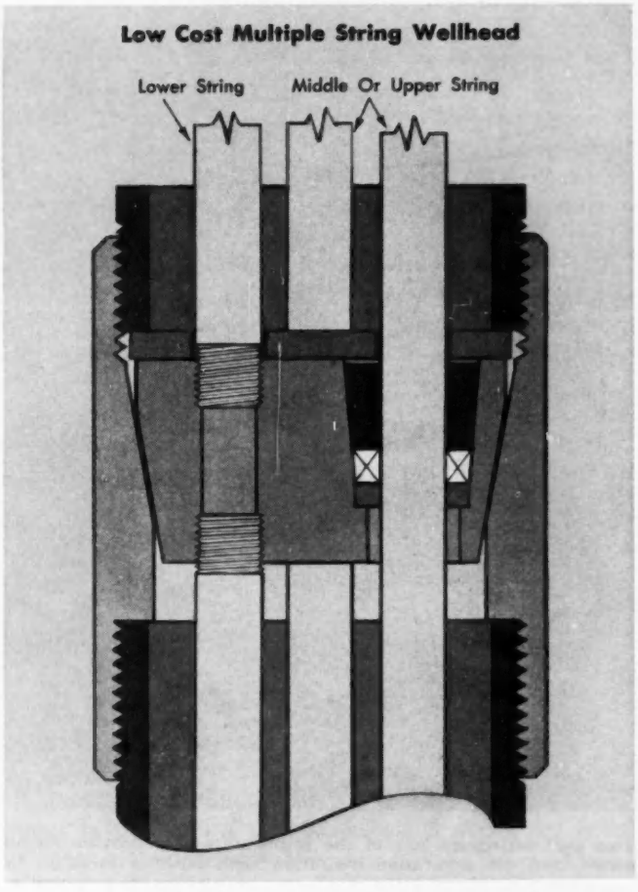
Wireline Drill Stem Tester



Entirely adequate samples of formation fluid have been obtained utilizing a wireline tester element in connection with a special drill collar which carries the tester-packer during routine drilling operations. Total elapsed time for these drill-stem tests, which require no trips, 2 hours for tests at 7,000 feet.



Retrievable production tubes permit operation of multicompletion wells throughout their normal producing lives without removal of the tubing.



Urgently needed is a low-cost wellhead to permit rapid, trouble-free landing and positive sealing of the multiple casing strings, run either independently or dependently.

However, full exploitation of this completion method requires accelerated development of:

1. A system of corrosion inhibitors whose falling rate in all types of formation fluids will be adequate to insure completion protection of the casing string without providing excessive shut-in time for the inhibitor to fall to the bottom of the well.

2. A low cost wellhead that will permit rapid, trouble-free handling and positive sealing of the multiple casing strings, run either independently or dependently.

In meeting the challenge of providing minimum cost wells of tomorrow, it should be emphasized that use of small-diameter tubingless completions, either single or multiple, will provide a tremendous impetus to develop casing that is more resistant to corrosion and erosion than today's oil country steel—and with internal surfaces that resist paraffin deposition. It is entirely possible that the tubular material will have enough flexibility to eliminate joints.

If the small-hole well of tomorrow appears to be a passing fancy, it should be noted that one operator drilled 437 wells having hole sizes ranging from 4¾ to 6½ inches. The total saving from this one program was nearly $3 million. The same operator completed 28 wells with 2½-inch oil string, and in many of the wells no tubing string was needed or used. Savings on these minimum cost wells exceeded 30 percent in many cases.

More efficient rigs, tubingless completions, multiple completions, slim hole drilling equipment and methods—all of these pose a real challenge to the modern engineer.

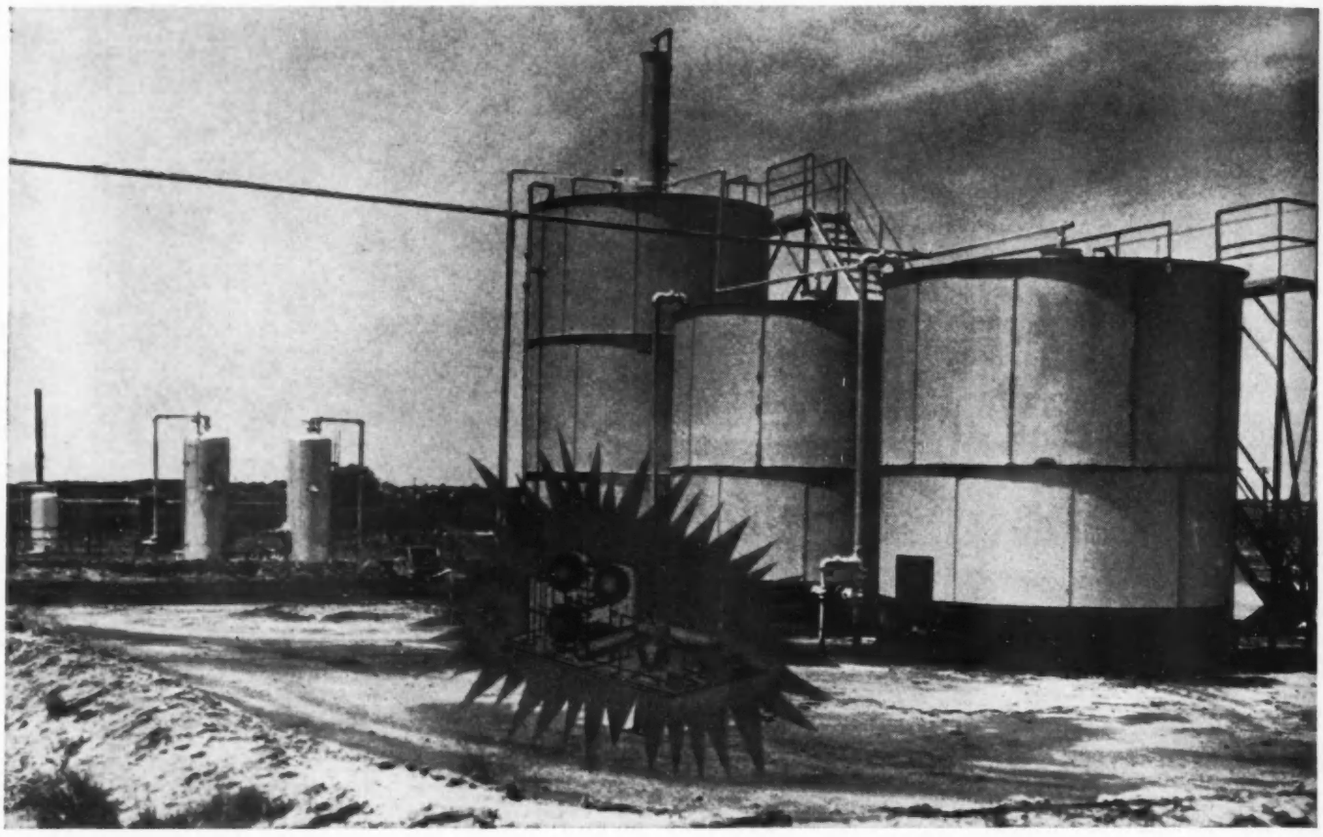
IMPROVED LEASE AND WELL OPERATIONS

Lease and well facilities account for a sizeable portion of the industry's annual $1 billion equipment purchases. Yet, despite this target, development of the past decade has been largely confined to providing equipment for higher pressure service, semi-automatic tank battery and well operation, and improved liquid recovery from gas.

The dawning industry-wide acceptance of automatic custody transfer equipment may be the most important technological contribution to lease equipment in the past decade.

Such a summary of dedicated and constructive effort could again lead to the conclusion that refinement is all that can be expected from continued development work in lease equipment. Conversely, a survey of the total requirements for separation, measurement and handling of oil, water and gas will definitely indicate a tremendous monetary return for a realistically sized, highly unitized facility.

Most urgent needs. The major challenge to mechanical engineering technology in the field of lease facilities is to develop realistically sized, major production units of high portability that can be interconnected on the lease at negligible cost with minimum piping to provide automatic unattended lease operation.



This unit represents one of the initial efforts to provide an oil, water, and gas separation operation with built in facilities for automatic custody transfer of oil and gas. Although mounted on a skid measuring 4 x 7 feet, the unit will perform all of the useful functions of a standard tank battery with a pipe line connection. This assembly, even custom-fabricated, still costs less than half as much installed as the conventional battery it replaced, yet it is even more portable than a pumping unit.

Some components must be developed to permit realizing the entire economic potential of automatic custody transfer, coupled with prepackaged, assembly-line production units. The more important developments needed include:

- A centrifuge for oil-water separation in the 2-3 horsepower class developed to yield a finished product of 99.9 percent purity instead of the 99.999 percent pure product yielded by current commercial centrifuges.

- A reasonably priced system to automatically compensate meter reading for water content in a merchandisable oil stream in cases where installation of centrifuges is not required for water-oil separation.

Certainly, men devoted to improving the mechanical technology of the industry will not overlook the possibilities of certain other equipment. For example, one operator has demonstrated in southern Louisiana that in highly faulted salt domes, it is feasible to inject gas as a means of recovering oil located structurally above the highest well. Gas injected for this purpose is lost unless another well is drilled. The process suggests a future need for highly compact, fully unitized, low-cost inert gas generators and compression units.

Also, numerous examples can be cited where relatively small developments will have tremendous utility. For instance, there is need for a low-cost unit that would permit withdrawing relatively limited mechanical or electrical energy from a flowing liquid stream for use at remote locations.

One application would be the offshore platform where energy loss resulting from the necessity to reduce pressure from 2,000 to 600 pounds per square inch could be utilized to generate the power required to operate safety and warning devices as well as provide energy needed for automatic operations.

Lease and well maintenance. Oil industry expenditures for lease and well maintenance are estimated at about $2 billion per year. It is obvious that the drilling of unnecessary wells with their continued maintenance is one way to increase production costs.

It has been acknowledged that the key to minimum operating costs is through planning of the entire lease and field development program with emphasis on the selection of facilities that in both size and simplicity provide optimum operation.

The unitized production facility with its automatic coding and well handling procedure should largely eliminate the last of the routine manual and clerical operations associated with producing and accounting for oil. Such automatic routing of lease production data will further open the door to complete machine accounting for production.

If even ten minutes of clerical time can be saved per run ticket eliminated, the saving becomes impressive when the number of run tickets necessary to sell the annual U.S. oil production of 2.5 to 3 billion barrels are considered.

If each ticket totaled as much as 500 barrels, the sav-

ings would be a million clerical manhours per year without consideration of similarly large savings in pumper and gager time.

Turning to gas accounting, field efforts are directed at measuring and recording static and differential pressures for eventual conversion to standard cubic feet or Btu's. In either event, much calculation time and many conversion factors are required to arrive at something which perhaps could be measured directly—the weight of fuel delivered.

The mass flow principle certainly offers hope of as great a simplication in gas measurement and accounting as the direct-recording positive-dump metering offers in oil.

Other aspects of mechanical ingenuity will be required to achieve fully the basic goal of an automatic unattended operation. For instance, there is not available a fail safe stuffing box.

Similarly, much work remains to be done in the broad areas of preventive maintenance and corrosion control to insure satisfactory long-term operations. Nevertheless, one major problem will be to bring about the broad understanding in all phases of the industry to insure full acceptance of this phase of technology.

MORE EFFICIENT REMEDIAL WELL WORK

The other major field of mechanical engineering technology in lease and well operations is the broad field of workovers, well servicing and artificial lift.

Developments in these areas have been impressive in the past decade, and, as mentioned earlier, these developments already have made the tubingless completion a reality. However, many of the 2½-inch wells of tomorrow will be equipped with 1½-inch or 1¼-inch tubing strings. Also, practically all of the workover, artificial lift and other associated equipment for the 2-inch tubing string of today must be made available at proportionate cost for use in these smaller sizes.

Similarly, technology in such fields as fracturing, where emphasis in the past has been on the high-rate, high-volume type of operation, must master such factors as sand falling rate, pumpability and fluid loss characteristics so as to permit satisfactory operation through smaller injection strings.

Early work in this direction has indicated not only satisfactory results, but also sharply reduced power requirements and thus reduced costs.

The smaller diameter wells and associated equipment of tomorrow will sharply reduce the size, cost and labor requirements for well service and workover units, thereby fostering the development of the integrated combination well service unit needed to eliminate up to six separate service units on location to perform a relatively simple reworking operation.

ADDITIONAL RECOVERY PROJECTS

Of the estimated 310 billion barrels of oil originally in proved fields in the United States, only 27 percent—or a little more than one-fourth of every barrel—can be economically produced by natural reservoir energy.

The elusive three-fourths of a barrel has been and still is a great incentive for the development and application of technology to result in its economical recovery. Say, for example, that the 73 percent of the oil left in the ground is whittled just 1 percent—down to 72 percent: The oil industry would recover another 3.1 billion barrels of oil!

Basically, two areas of applied technology are resulting in additional recovery. First is the development of more efficient and less expensive means of producing oil so reservoirs operating under natural drives can be carried to a greater degree of depletion.

However, the real promise of increased recovery lies in the area of applying technology to control reservoir energy and fluid properties. In this area, the technology of altering physical properties appears to be on the threshold of a major breakthrough.

Waterflooding is the oldest and the most successful of the additional recovery techniques. In 1948, water injection operations accounted for only 80,000 barrels per day. Last year, waterflood production averaged almost 600,000 barrels per day or 8.5 percent of the U.S. total.

Waterflooding probably will continue to be the mainstay of additional recovery technology in the immediate future, but the problem of suitable floodwater supply looms on the horizon. Here, certainly, is a fertile field for applied technology.

Gas injection into reservoirs is another technique that has enjoyed widespread acceptance in the past. Recent developments have proved once again that a high percentage of oil originally in place can be recovered with gas injection under favorable reservoir conditions. These techniques include the enriched gas process, high-pressure gas injection, LPG flood, and simultaneous gas and water injection.

Also, several new additional recovery processes are beginning to show promise. Some examples are thermal recovery techniques such as in situ combustion, steam and hot water injection, and the injection of hot gases, such as engine exhaust. Injection of air, inert gases and carbon dioxide dissolved in water are being tried, too.

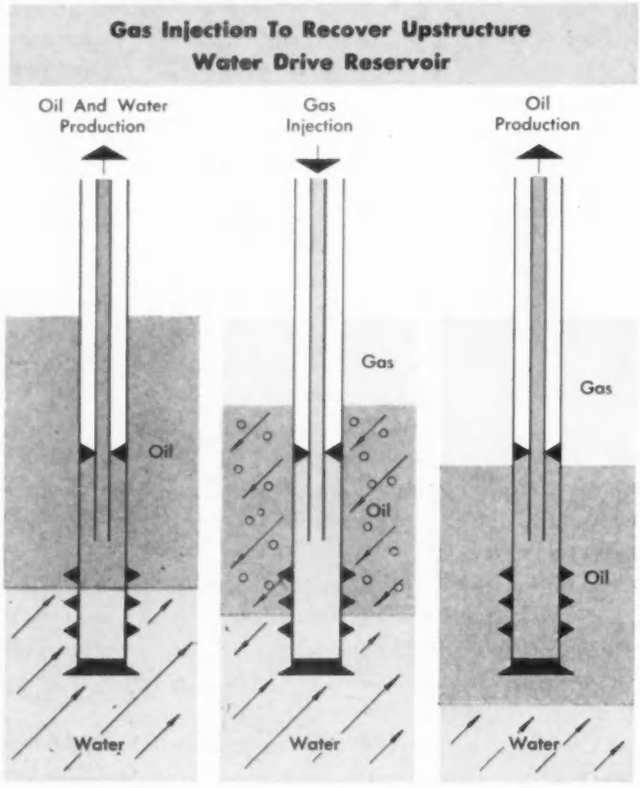
Many other methods deal with the changing of rock properties that hold promise of additional recovery—provided engineering skill is equal to the task of developing them.

EFFICIENT WELL SPACING

It is unfortunately true that in the past the industry has not taken full advantage of its scientific knowledge. Competition from low-cost foreign oil, however, is putting pressure on oil companies to apply all of their technical know-how—not only to produce as well as they know how, but to step up the pace of technological development.

A few comparisons point up the kind of competition that the domestic industry is facing today. In the United States, there is an average reserve of only about 60,000 barrels of oil for each producing well. Each well competes with a well in Venezuela with a reserve of over 1 million barrels, and a well in the Middle East with a reserve of over 270 million barrels.

Then consider producing rates. The average well in this country produces about 13 barrels per day, compared



One operator has demonstrated in southern Louisiana that in highly faulted salt domes it is entirely feasible to inject gas as a means of recovering oil located structurally above the highest well. Gas injected for this purpose is lost unless another well is drilled for its recovery. The process suggests the future need for a highly compact, fully unitized, low-cost inert gas generator and compression unit.

with 200 barrels per day in Venezuela and over 5,000 barrels per day in the Middle East.

One of the main reasons why the U.S. oil industry comes out on the short end of these comparisons is that operators knowingly drill on close spacing patterns. This has contributed directly to low per-well reserves. Furthermore, it has severely weakened the industry's ability to continue finding new reserves to meet the country's ultimate requirements.

Technology already has proved that oil can be efficiently drained over extremely wide distances at realistic producing rates. Technical literature is abundant with laboratory and field performance data which show that oil can be properly drained over wide areas even in extremely tight formations of varying permeability.

Too many do not know the truth. Scientific aspects of well spacing have long been understood, but outmoded concepts have hung on. A typical misconception is that wide spacers want to apply a fixed spacing rule to all fields, regardless of geology, but this is not so. Advocates of efficient well spacing have never contended that a hard and fast spacing rule should be applied across-the-board in disregard of physical facts.

Another misconception is that advocates of wide spacing are trying to squeeze out the small tract owner and deprive him of his rights. Rights of the small land or tract owner must be protected—but that protection should not permit drainage from the adjoining tracts.

Still another misconception is that wide spacing will lead to the drilling of fewer wells and would have a detrimental effect on the economy in general and allied equipment and service companies in particular. It is hardly conceivable that a healthy and expanding industry would drill fewer wells. Sensible well spacing would free capital, men and equipment for this discovery of new reserves and the establishment of conservation projects to increase recovery from existing fields.

IMPROVED EXPLORATORY TECHNIQUES

Another major means by which the oil industry can achieve important cost reductions is through improvements in exploratory methods and equipment.

Several opportunities exist for cost reduction through such devices as improved subsurface analysis and correlation, improved seismic recording using magnetic tape, and improved core drilling equipment.

Another opportunity lies in development of techniques for location of oil accumulation in stratigraphic traps. Only a small portion of the cubic area which is potentially oil bearing in this country has yet been tested by drilling. Much oil remains to be discovered in stratigraphic traps which can seldom be located today except by costly drilling operations.

A scientific breakthrough which would give the industry a means of locating stratigraphic traps economically would significantly reduce finding costs.

The odds against finding oil through sheer luck are becoming so prohibitive that more and more emphasis must be placed on scientific methods, and greater amounts of time and money must be spent for these purposes.

INCREASED RESEARCH

Perhaps the most important cost saving device of all is increased research in all phases of oil finding, developing and lifting activities. Imagine for a moment what would happen if the same kind of intensive, creative scientific effort could be directed into the oil industry that went into the development of the hydrogen bomb, atomic submarines, earth satellites, and the recent moon rockets!

If the formidable technological problems involved in these developments can be solved, is it too much to expect that better ways of locating oil, cheaper means of drilling holes, and better techniques to increase oil recovery can be developed?

The oil industry always has prided itself on being progressive. How, then, is it possible to account for the fact that research expenditures are relatively low compared with many other major industries in the United States?

Total money spent in all phases of exploration and production research is estimated at about $40 million per year, which is less than 1 percent of the entire industry's estimated capital expenditures.

(Information and illustrations contained in the subtitles Sizing of Lease Well Equipment, Lease and Well Operations, Remedial Well Work, Recovery Projects and Well Spacing were obtained from papers presented by Harry Pistole and Martin E. True, Humble Oil & Refining Company, at September 1958 American Society of Mechanical Engineers meeting, Denver, and from a speech presented by James H. Galloway, Humble Oil & Refining Company, before the Southwest Texas Section of the Society of Petroleum Engineers of AIME, Corpus Christi, Texas, September 16, 1959. Other information was obtained from industry associations, government sources and speeches by L. F. McCollum, president of Continental Oil Company.)

How one company determines cost

By R. E. Megill, Senior Economist
The Carter Oil Company, Tulsa

Most businesses know what their costs are. Plants can be built, products made and a cost per product determined.

But, the oil industry is not quite so fortunate. Spending money in exploration does not guarantee finding oil. If oil is found, the quantity is not immediately known; and, seldom is the cost of finding per barrel known soon enough to have its proper influence on current decisions.

About the only thing the public knows about producing oil companies is that they make profits. Many companies are not able to tell where these profits originate, because of their inability to allocate costs. Profits may be coming from older fields, but this is difficult to express quantitatively. The petroleum industry needs more facts.

One of the vital facts the industry needs to know is its cost of finding oil. Only by comparing the amount of money spent looking in an area to the barrels found in that area can the industry judge the efficiency of its exploration program.

Following are the methods The Carter Oil Company uses to estimate the number of barrels found in a given field, plus a suggested plan to calculate the amount of money the oil industry is spending to find oil and gas.

How reserves are determined. In determining the costs of finding, many people use American Petroleum Institute reserve additions as indicative of barrels found. If a very long period is considered, this is reasonably accurate. The disadvantages on a short-range basis are many.

For example, reserve additions resulting from waterflood projects in old reservoirs are not a result of current exploration; they should be credited to earlier exploration programs. Waterflood reserve additions cannot be segregated in using API data. Similarly, major revisions (up or down) in old fields are not a result of current exploration efforts. These changes also cannot be isolated from API data.

The results of current exploration programs can be determined only by considering the new reservoirs found during the period. Finding expenses should be related to the barrels of oil found in these reservoirs. Determining the proper barrels to relate to current costs necessitates adding to current reserve data an estimate of future reserve additions.

Following is the method used to estimate reserves in this analysis:

- All petroleum reservoirs are separated by year of discovery.
- Current estimates of reservoirs are tabulated by year of discovery.
- Current estimates are statistically corrected for future reserve additions, both primary and secondary.

This method adjusts the barrels found and developed to a probable final basis.

Calculation of finding costs. To calculate the cost of finding in a specific area, the basic exploration facts must be assembled. These include the number of employed geologists, the amount of geophysical work performed, the number of employed scouts, the undeveloped acreage holdings, and the number and average depth of dry holes.

Geological costs can be calculated by multiplying the

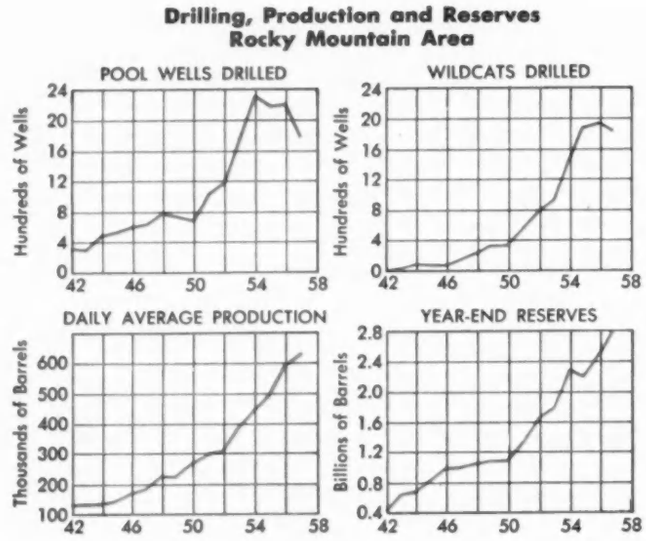


FIGURE 1

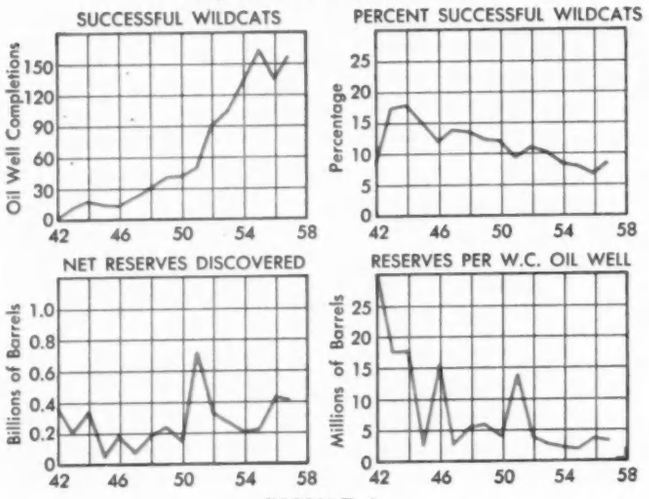


FIGURE 2

number of employed geologists by the cost per year to arrive at total geological cost. The number of employed geologists can be estimated from the American Association of Petroleum Geologists' mailing list.[1]

Total seismograph cost can be estimated by multiplying the cost per crew per month by the number of crew months worked. Scouting costs are estimated in the same manner as geological costs.

Using drilling cost data published by the Joint Survey, the cost of dry holes can be estimated. Acreage holdings have been published for some time by the Independent Petroleum Association of America and other sources.[4, 5, 6] From these holdings, the number of acres acquired and leased are estimated. Surrendered lease cost, annual rentals and leasing costs are determined by multiplying cost per acre factors times the appropriate acreage.

This describes briefly the technique used to estimate the cost of finding for a given area. Basically, it is the application of dollar costs to various physical factors that can be estimated or measured in a particular area.

These costs included money spent looking for gas. No attempt is made here to allocate costs for gas found. There is no general agreement in the industry on how this should be done. Those interested in correcting these costs can apply their own allocation techniques to the total dollars spent. Such a correction is obviously more important in some areas than others.

Meanwhile, it must be remembered that the cost-per-barrel numbers quoted here are slightly higher by whatever amount would be allocated to gas. Such allocation, however, will not affect the general conclusions of this analysis concerning the trends in finding costs.

Following is a sample cost analysis for the Rocky Mountain area, and for the interior United States:

ROCKY MOUNTAIN COST OF FINDING

The area included in this cost report includes Idaho, Montana, North and South Dakota, Wyoming, Nevada, Utah, Colorado, and the western panhandle of Nebraska. The effect of recent intensified exploration in this area is indicated by the four graphs in Figure 1.

Pool drilling peaked in 1954 with almost 2,400 completions; 1957 completions totaled about 1,800 wells. Wildcat wells peaked in 1956 and were at about the same level in 1957—1,800.

Rocky Mountain production in 1957 was 630,000 barrels per day, six times the production rate in 1942. Remaining reserves at year-end 1957 were seven times the 1942 level.

Discovery data. Successful wildcats increased from less than 10 in 1942 to more than 150 wells per year in 1955. (See Figure 2). Since 1943-44, there has been a gradual decline in the success rate; the current level of 7½ percent is a decrease from the high of 18 percent in 1944.

At the same time, crude oil reserves discovered per wildcat oil well drilled have decreased. The average size of discoveries was 10-15 million barrels in the early 1940's. Since 1953, the average successful wildcat has found 2.5 million barrels. However, because of the increased number of wildcats drilled, the amount of reserves per year has been tremendously upward since 1944.

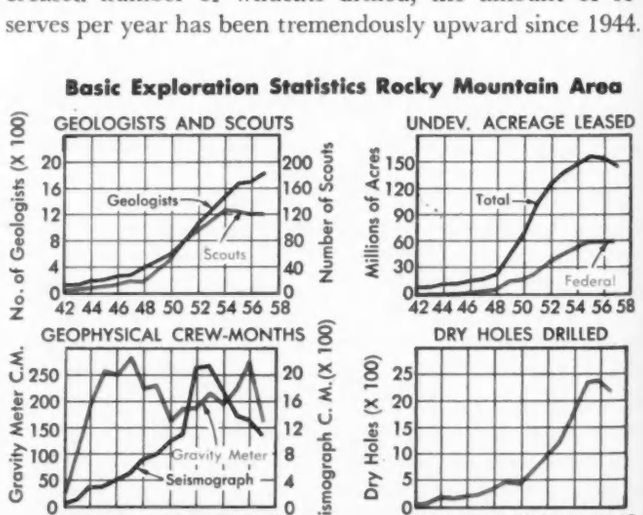


FIGURE 3

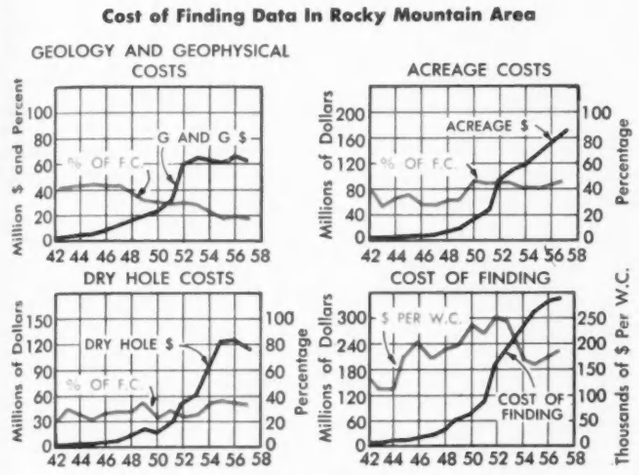


FIGURE 4

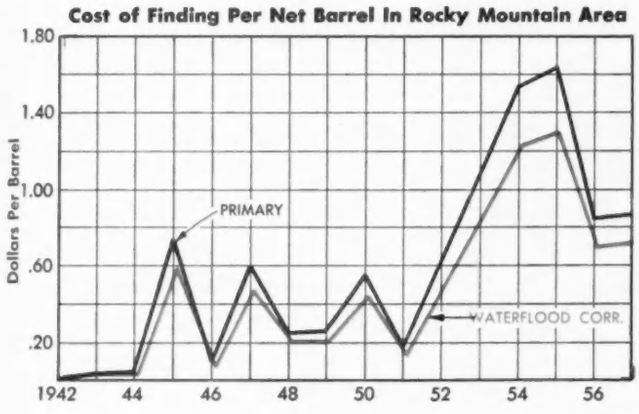


FIGURE 5

Since 1942, more than 5 billion barrels have been found in the Rocky Mountains.

Exploration statistics. The number of employed geologists has increased rapidly in the area since 1942. At present, there are almost 2,000 geologists in the Rocky Mountain states, with more than 120 scouts employed (See Figure 3).

Seismograph crew months increased gradually until 1951, when 1,200 crew months were reported. The discovery of oil in the Williston Basin jumped seismograph activity to 2,100 crew months in 1952 and 1953. Since that time, crew months have declined to the 1951 level. Another peak was reached in 1956, but in general gravity meter work in this area is declining.

Following a rapid increase in exploratory activity after 1950, acreage holdings reached a peak of 150 million acres in 1955. Dry holes also increased rapidly after 1950, peaking at about 2,500 in 1956.

Converting statistics to dollars. The petroleum industry spent about $60 million on geology and geophysics in the Rocky Mountain area during 1957. This was 20 percent of the finding costs (See Figure 4).

Acreage costs amounted to 40 percent of the cost of finding, totaling about $160 million. Much of this was in rental costs which increase as each area is leased the second time.

Dry hole costs amounted to $120 million per year in 1955, 1956 and 1957—almost 40 percent of the finding cost.

The total amount of money spent looking for oil in the Rocky Mountains reached a peak of about $350 million in 1957. This was a cost per wildcat of almost $200,000, or at a 7½ percent success rate, $2.5 million per successful wildcat.

These dollars compared with the net barrels found provide a cost of finding per barrel, as shown on Figure 5. Finding costs per barrel in the Rocky Mountain area are among the lowest in the United States, but have increased significantly since 1946, reaching a peak in 1954-55. In 1957, finding costs were about 70 cents per barrel, including a correction for future waterflood reserves.

The money spent in any one year looking for oil or gas may have only an indirect relationship to barrels found. Some leases bought today will be drilled in subsequent years. Some of the prospects uncovered by geologists and geophysicists will be drilled later. However, by considering a 16-year period, the finding cost trend can be established.

U.S. INTERIOR COST OF FINDING

The yearly cost of finding oil, primary and secondary, is shown for three areas on Figure 6. These areas comprise most of the interior U.S. They include Kansas and Oklahoma, the Illinois and Michigan Basins, and the Rocky Mountain area.

In 1957 the Rocky Mountain area had the lowest finding costs of the three areas. During that year, finding costs were about $2 per barrel in the Illinois and Michigan Basins, $1.30 per barrel in Kansas and Oklahoma, and 70 cents per barrel in the Rocky Mountains.

The average costs over various periods are as follows:

Cost of Finding Per Barrel

Area	$ Per Net Barrel 1942-57	1954-57
Kansas-Oklahoma	0.57	1.04
Illinois-Michigan Basins	0.70	1.26
Rocky Mountains	0.41	1.07

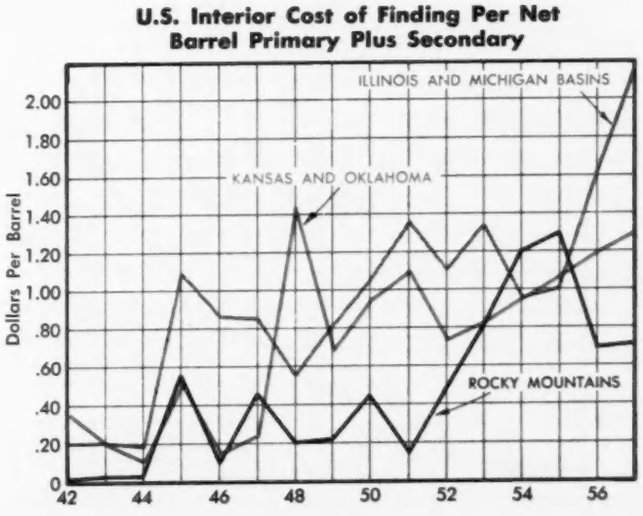


FIGURE 6

Replacement costs per barrel. By making additional calculations of development and operating costs of the areas, an interesting comparison can be made between replacement cost per barrel (the sum of finding, developing and operating costs per barrel) and the average crude price in the area. These comparisons are made on Figure 7.

It is immediately apparent that the Rocky Mountain area has had the most favorable relationship between replacement cost and crude price per barrel. However, the need for an increase in finding efficiency—to lower replacement costs—is apparent in all areas.

The fact that there is a relationship between replacement cost and crude price indicates that either replacement cost is restricted by crude price or that crude price is pressured upward by replacement cost.

Probably, neither is completely correct. Crude prices are affected by other factors also:

- The price of competing crudes at refining centers.
- Prices of products made from crude oil.
- Price or costs associated with competing fuels.

The cost of any commodity must eventually be reflected in its selling price. However, other factors sometimes restrict prices. In such instances, the industry has only one alternative—lower its costs.

Cost reduction is particularly important now, because the cost of finding oil per barrel is rising more rapidly than development and operating costs per barrel. Furthermore, it will continue to do so in the future.

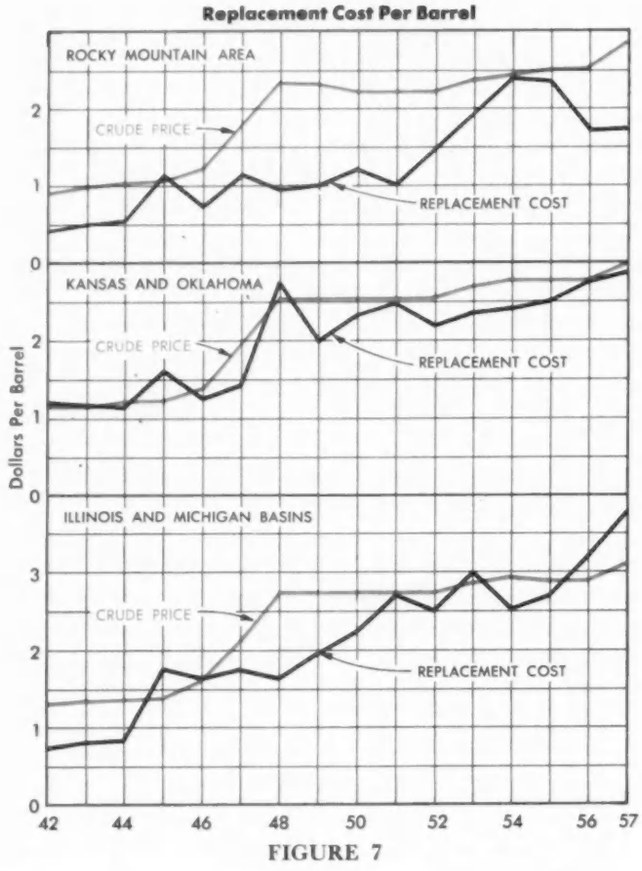


FIGURE 7

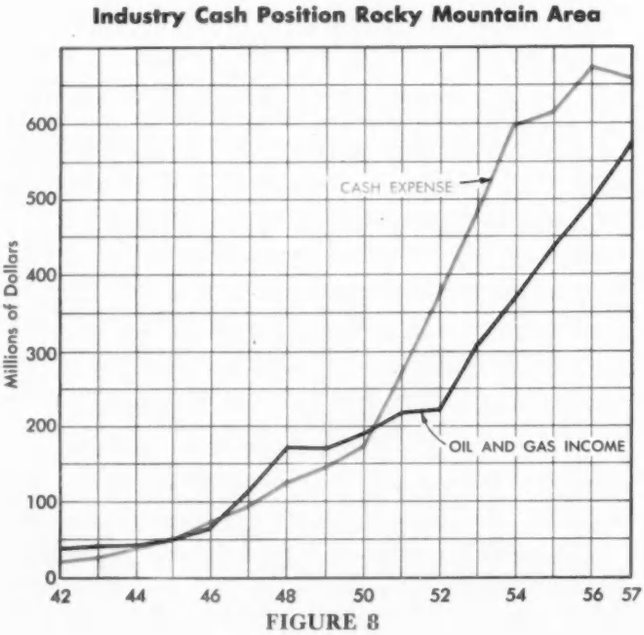


FIGURE 8

Cash position. In any new exploration area, huge sums of money are spent finding and developing new reserves before any money is returned. The rapid expansion of the Williston Basin, coupled with the activity in the Denver and Paradox Basins accentuated the difference between income and outgo.

Between 1950 and 1957 the oil industry accumulated a $1 billion deficit in the Rocky Mountain area (See Figure 8). This deficit emphasizes the huge cash requirements of the petroleum industry.

Sufficient reserves have been added to the Rocky Mountains to more than offset the deficit. However, it will be some time before the deficit is erased.

Needed: Accurate Cost Figures. The producing phase of the oil industry is handicapped as few industries are by lack of current data as to the success or failure of its exploration (investment) efforts. Some of the most worthwhile additions to petroleum statistics have been the publication of the Joint Survey. However, these are hardly more than a very small beginning. Much more data needs to be published, and preferably on an area basis.

If the U.S. petroleum industry is to survive the intense competition with other crude suppliers of the world, it must become more familiar with its costs. It must find where the best opportunities lie for reasonable profits.

(Presented at the Forty-Fourth Annual Meeting of The American Association of Petroleum Geologists, Dallas, March 1959.)

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[2] April, 1956, "Petroleum Industry Income and Expenditures in the U.S." A report by the Joint Association Survey (API, IPAA and Mid-Continent Oil & Gas Association).

[3] December, 1955, "Expenditures for Drilling and Equipping Wells in 1953." A report by the Joint Association Survey.

[4] IPAA, "The Oil Producing Industry in Your State," published biannually.

[5] National Scouts and Landmens Association Yearbook.

[6] Statistical Abstract of U.S. (Public Lands).

Valuable "self-help" articles are on the following pages. Be sure to read . . .

Can equipment leasing cut production costs?

. . . shows how two independent producers have benefitted from equipment leasing. Page 123.

How to improve LACT performance

. . . describes operation of a new instrumentation package designed specifically for LACT service. Page 129.

How to handle high strength drill pipe

. . . discusses advantages and uses of new hoisting methods. Page 117.

Preventing equipment failure in sour gas-condensate wells

. . . explains Shell Oil Company's method of determining the corrosivity of each new well stream and how to use this information to select proper resistant equipment and appropriate completion practices. Page 125.

Geologists' interpretation of drilling mud requirements

. . . presents a logging method which the author believes will yield optimum evaluation for each general type of drilling mud. Page 133.

How new additives improve deep well cementing

. . . here are the new cementing techniques Phillips Petroleum Company used in drilling three deep tests in Pecos County, Texas, during 1958. Page 140.

80-acre spacing sufficient to deplete primary oil

. . . presents a case history showing how wider well spacing provided excellent primary recovery and now serves for water flood operations in the Horsehead field, Arkansas. Page 146.

FIGURE 1—These sulfate reducing bacteria were responsible for most of the corrosion experienced by Continental Oil Company on the Bozeman lease. These specimens were isolated from produced water and are shown here magnified 44,000 times.

Corrosion is controlled by bactericide treatment

Conoco reduced well equipment repairs 59% by treating producing wells in Indiana with bacterial control agents instead of inhibitor

By R. C. Allred, Research Group Leader,
J. D. Sudbury, Supervising Research Chemist, and
D. C. Olson, Senior Production Engineer,
Continental Oil Company, Ponca City, Okla.

BACTERICIDES recently were applied successfully to prevent corrosion in producing wells on Continental Oil Company's Bozeman Land Company lease near Griffin, Ind. Conventional corrosion inhibitor treatment previously had been used on the lease without success. Application of bactericides

alone (without corrosion inhibitor) reduced pulling jobs 59 percent. A 77 percent reduction in corrosion rate also occurred.

In oil field operations, produced fluid may contain large numbers of sulfate reducers, Where corrosion is a problem and conventional corrosion inhibitors have not performed satisfactorily, the corrosion inhibitor may have to be supplemented with a bactericide to obtain maximum corrosion protection. Prior to the use of a bactericide, a bacterial analysis should be made on the produced fluid at the wellhead to make sure that sulfate reducing bacteria are present.

Field evidence shows that sulfate reducing bacteria, when present, can play an important role in corrosion of producing well equipment. Control of these bacteria can provide a substantial reduction in corrosion rates.

It has been noted that while some corrosion inhibitors perform well in laboratory tests they have failed in field use. When this occurs, it is always assumed that the laboratory test is at fault. In view of past results, it is possible that the poor showing of a corrosion inhibitor in the field could be due to its inability to control sulfate reducing bacteria.

The role of sulfate reducing bacteria in iron corrosion was first defined in 1934.[1] The theory was advanced that these organisms could accelerate anaerobic galvanic corrosion through an ability to act as depolarizing agents. This work was confirmed and expanded by other investigators.[2, 3]

Most previous work on microbial corrosion has been limited to the effect of sulfate reducing bacteria on the corrosion of oil and gas transmission lines. Little information is available about the effects of these organisms on down-hole equipment in producing wells. This study was made to determine the importance of sulfate reducer control as related to corrosion control in producing wells.

Experimental methods and results. To define the role of sulfate reducing bacteria in corrosion of producing well equipment, the following procedure was set forth. Producing wells with a high sulfate reducer count and a long history of excessive pulling jobs would be used for the test. The wells would be treated with a bactericide that had no corrosion inhibiting properties, and all subsequent changes in corrosion rates and pulling jobs recorded. Under these conditions, any reduction in corrosion would be the result of bacterial control.

Sodium tetrachlorophenate was the chemical selected for use in the test. This material had no corrosion inhibiting properties and was effective against sulfate reducing bacteria at concentrations of 15-20 ppm. Later in the field test, 2,2′ methylene bis (4 chlorophenol) (sodium salt) was substituted for the tetrachlorophenate.

The latter chemical was available in liquid form while the former was obtained as a powder. The newer chemical was somewhat more effective as a bactericide. It also had no corrosion inhibiting properties.

Four Tar Springs producers were selected as test wells from the Bozeman Land Co. lease. This lease was operated by Continental Oil. Prior to the test, these wells had been treated unsuccessfully with a combination of formaldehyde and polyphosphate. The wells all had a sulfate reducer count of over 10,000 organisms per milliliter of water. Complete records on pulling jobs and corrosion rates over an extended period also were available.

Table 1 shows the reduction in rod, tubing and pump jobs over a one and one-half year period while the wells were being treated with the chlorinated phenol type bactericides. The four wells averaged a 59 percent reduction in pulling jobs. Sulfate reducer counts were reduced from over 10,000 per milliliter to less than 10 per milliliter. These data indicate that in these wells sulfate reducing bacteria were responsible for about 59 percent of rod, tubing and pump failures.

Corrosion rates as measured by weight loss on mild steel coupons are given in Table 2. An average reduction in corrosion rates of about 77 percent occurred with the bacterial control agent. Since the bacterial control agents had no corrosion inhibiting properties, it must be concluded that sulfate reducing bacteria were responsible for more than 77 percent of the corrosion occurring in these wells.

TABLE 1—Data shown here indicate a 59 percent per month average reduction in rod, tubing and pump repairs when bactericides were used in lieu of corrosion inhibitor.

	ROD, TUBING, AND PUMP REPAIRS PER MONTH		
WELL	Polyphosphate Formaldehyde Treatment	Bactericide[1] Treatment	Percent Reduction
Bozeman 46	0.75	0.44	41
Bozeman 54	1.00	0.13	87
Bozeman 55	1.11	0.33	70
Bozeman 56	0.22	0.13	41
Average	....	....	59

[1] Bactericide treatment 25 ppm for 18 months.

TABLE 2—Corrosion rates in MPY for the four test wells are shown here. An average reduction in corrosion rate of about 77 percent was realized when only bactericides were used.

	CORROSION RATES—MPY		
WELL	Polyphosphate Formaldehyde Treatment	Bactericide[1] Treatment	Percent Reduction
Bozeman 46	17.4	3.5	80
Bozeman 54	12.0	3.0	75
Bozeman 55	9.0	2.0	78
Bozeman 56	10.5	2.5	76

[1] Bactericide treatment 25 ppm.

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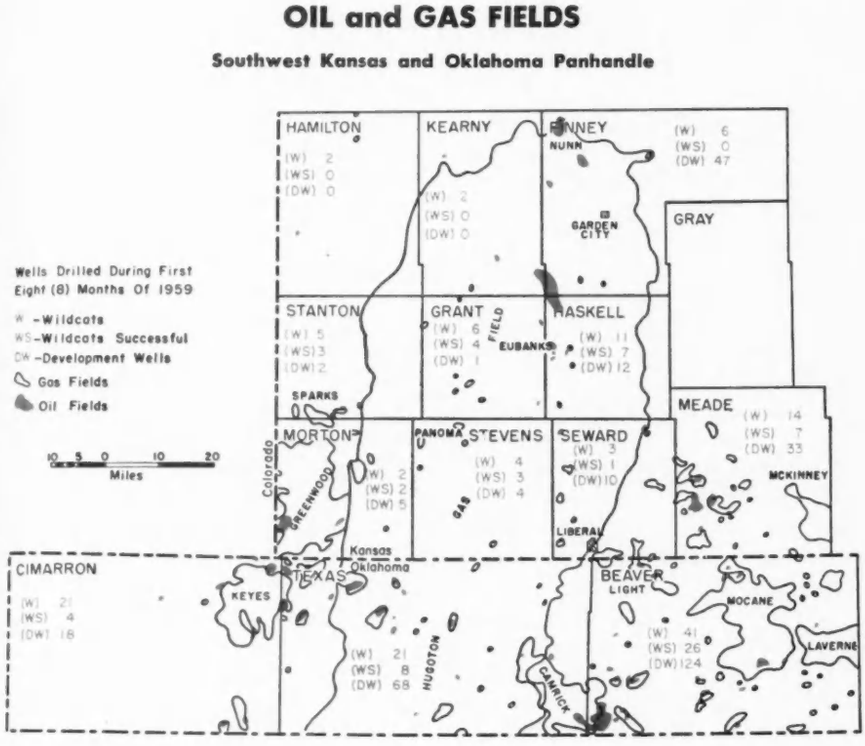
This month's report on what's new in equipment, services and literature begins on Page 202



New activity in Southwest Kansas-Okla. Panhandle

Exploration and development are proceeding briskly in Beaver County, Oklahoma, and in Seward-Meade counties, Kansas

By R. S. Buchanan, Consulting Geologist
Liberal, Kan.

EXPLORATION AND DEVELOPMENT activity is booming in 10 southwest Kansas counties and three counties in the Oklahoma Panhandle.

During the first eight months of 1959 operators marked up the following record in Kansas (for the specific area, see map):

- 57 wildcats drilled, 28 of which were producers.
- 92 deep development wells completed, plus 24 shallow wells.

The record in three Oklahoma counties:

- 83 wildcats drilled, 38 of which were producers.
- 206 deep development wells, plus 4 shallow wells.

In late October, 13 wells were drilling, 3 locations had been staked and 19 wells were in various stages of completion in the 10 southwest Kansas counties.

In the three Oklahoma Panhandle counties, 30 wells were drilling, 7 locations had been staked and 22 wells were in various stages of completion.

A number of factors have contributed to the increased activity in Southwest Kansas and the Oklahoma Panhandle. Among these are:

1. Multiple pay prospects exist over much of the area.

2. Lease expirations due within the next few years demand peak development and exploration programs.

3. Shallow Hugoton field well control serves as ready made core drill data for deeper drilling objectives within the Hugoton field.

4. Recently available oil pipe line outlets have made oil prospecting more attractive.

Geographical location has rendered Liberal, Kan., a natural center for oil and gas activity in the two-state area. Here many operating companies, service companies and supply stores have established offices. Most of the area is well served by highways leading to Wichita, Denver, Oklahoma City and Amarillo. Rail facilities and air transportation are available at Liberal and Garden City. Flat or gently rolling topography renders transportation a minor problem.

Geology. In a geological sense, southwest Kansas and the Oklahoma Panhandle occur at the northwest end of the Anadarko Basin. With the exception of southeastern Beaver County, Oklahoma, which falls on the northern basin flank, most of the two-state area shown on the maps occurs on the Northern Basin Shelf of the Anadarko Basin.

Dominating the area as major structural features are the Cimarron uplift of eastern Cimarron County, Oklahoma, and western Morton County, Kansas, and, adjacent on the east, the Hugoton Embayment.

The majority of proven production is now being obtained from sediments of lower Permian, Pennsylvanian and upper Mississippian age. Lower Permian productive horizons are in most cases carbonate over the entire area.

With the exception of the lower Pennsylvanian Morrow series which is primarily a sand and shale sequence, the Pennsylvanian shelf facies is a carbonate formation.

At the break from the shelf area to the northern basin flank in southeastern Beaver County, upper Missourian carbonate sediments exhibit an abrupt change of facies to a shale and sand (Tonkawa) sequence.

Upper Mississippian (Chester) rocks east of the Hugoton field consist primarily of shales and limestones. Under the Hugoton field lower Chesterian sediments exhibit a facies change to a sand and shale section. Pay sections of the Mississippian St. Louis formation consist of coarse oolitic limestones with excellent porosity and permeability.

Commonly used markers are the Winfield formation of the Chase Group, the Heebner shale, the top of the Morrow series and the top of the Mississippian.

Discovery methods. Gravity and seismic data when coupled with subsurface information have formed a good combination for prospecting for structural traps.

Subsurface methods alone have located the majority of the stratigraphic traps. Hugoton field well core drill data, coupled with subsurface methods, form a useful combination for deep prospecting for structural traps in the Hugoton field.

Stratigraphic and structural-stratigraphic traps at the present time account by far for the greater part of existing production in the two-state area.

Development history. During 1948-1953, large scale lease campaigns were under way throughout most of the area. During the latter part of this period, development work was started in the Keyes field, northeastern Cimarron County, Oklahoma; Greenwood field, western Morton County, Kansas; Liberal-Light pool area, southern Meade County and northwest Beaver County; and in the Novinger Pool, Meade County.

From these early centers of interest, exploration and development has spread in all directions.

Recent trends. A recent trend toward deep exploration and development within the confines of the Hugoton field has been noted during the past two years. Core drill data offered by shallow Hugoton field wells give invaluable subsurface information in probing for deep structural and structural-stratigraphic traps.

As a result of this deep drilling, oil production has been found in St. Louis reservoirs in the Pleasant Prairie field and in the Chester sands in the Eubanks pool area of Haskell County, Kansas. Other results of deep Hugoton field exploration are the location of what appears to be a sizable Council Grove Group gas reservoir in Stevens and Grant counties, Kansas, and a possible extension of upper Morrow sand production from the prolific Camrick field area of southeast Texas and southwest Beaver Counties northwestward to the Keyes field area.

Elsewhere, exploration and development are proceeding briskly in Beaver County, Oklahoma, and in Seward and Meade Counties, Kansas. West of the Hugoton field significant discoveries have been made in Hamilton County, Kansas, where a major westward extension of the Hugoton field pays appears likely—in Stanton County, Kansas, where upper Morrow sand production has been extended—and in southeastern Cimarron County Oklahoma, where reservoirs ranging from the Chase Group to the Morrow have been proven productive.

Spacing. Development of gas productive acreage in both Kansas and Oklahoma has been on 640-acre units. In Oklahoma, where possible, the unit must fall within a governmental section. This requirement is not necessary in Kansas, but in most cases the unit acreage must be contiguous.

Although oil development has been largely on a 40-acre spacing pattern in both states, there has been a recent trend in Kansas in the Pleasant Prairie-Eubanks Pool area to 80-acre spacing.

Lease situation. Presently and for the next few years lease expirations come due on a number of undeveloped leases taken during the 1948-1953 period. As a result of this situation, a maximum exploration and development program appears imminent for the coming five-year period.

In most cases, deep rights under the Hugoton field are held by shallow well production, and the incentive to farm out these rights is not as strong as for leases outside the field. Some farmouts have been made, however, and Shell Oil Company is drilling on a 20-well program obtained from one of the major Hugoton field leaseholders.

Drilling operations. Nearly all drilling operations are conducted with jack-knife rotary rigs. Depth limitations range from 6,000 feet to 7,500 feet. Butane is the most common fuel although in some cases diesel is used.

The use of standby mud pumps is a common practice. Both steel and earthern mud pits are used. Two thousand pound working pressure blowout preventers are most commonly seen. Hole size ranges from 7⅞-inch to 8¾-inch.

A typical casing program calls for 300 feet to 600 feet of 13⅜-inch surface casing, 2,500 feet to 3,000 feet of 8⅝-inch intermediate casing, and 5½-inch production string. In areas

Most Active Areas

The most active Kansas counties are Meade (14 wildcats and 33 development wells completed during the first eight months), Finney County (6 wildcats and 47 development wells), and Haskell County (11 wildcats and 12 development wells).

Most of the current activity is in the Pleasant Prarie Pool in Finney and Haskell counties, the Eubanks Pool in Haskell County—and in the Pennsylvania limestone, Morrow sands and Chester limestone in Meade County.

About 75 percent of the wells are gas in Meade County, while nearly all the wells are oil in Haskell and Finney counties.

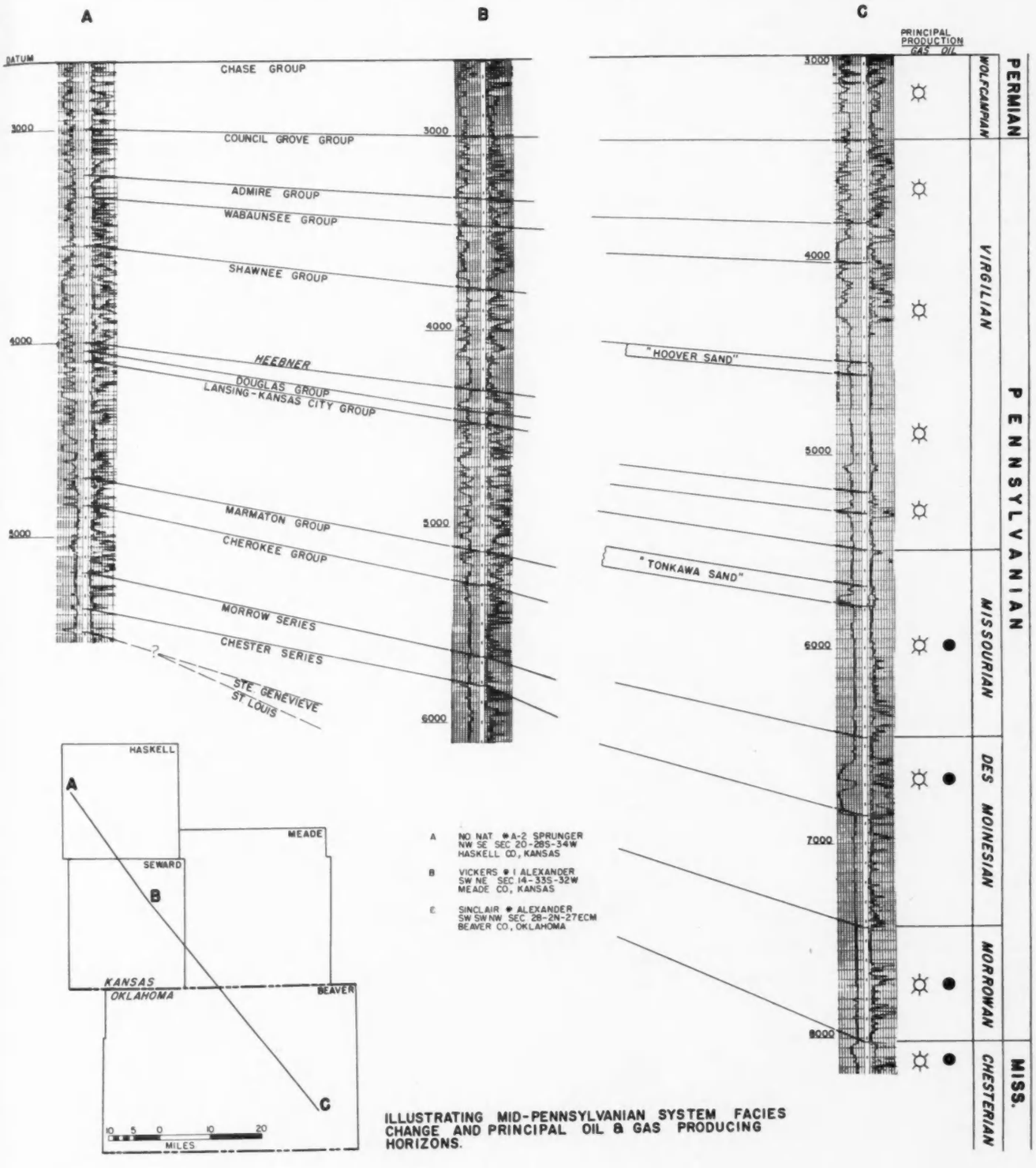
Beaver County is by far the most active area in the Oklahoma Panhandle with 41 wildcats and 124 development wells completed during the first eight months.

In Texas County, 21 wildcats and 68 development wells were completed. The record in Cimarron County was 21 wildcats and 18 development wells.

About 75 percent of the wells in the three Oklahoma counties are gas.

Cross-Section of Southwest Kansas and Oklahoma Panhandle

(Illustrating Mid-Pennsylvanian System facies change and principal oil and gas producing horizons.)



ILLUSTRATING MID-PENNSYLVANIAN SYSTEM FACIES CHANGE AND PRINCIPAL OIL & GAS PRODUCING HORIZONS.

of excessive surface sand along river bottoms some operators set 50 feet to 100 feet of 20-inch conductor string before running surface casing.

Some companies prefer, particularly on development wells, to eliminate the intermediate casing and to drill the well to total depth with a starch mud. The savings of this type of casing program is obvious, but is in many cases offset by the following disadvantages:

1. In some areas the "Glorietta Sand," which occurs between the Blaine gypsum and the Cimarron anhydrite, is a notoriously bad lost circulation zone.

2. Hole conditions and sample quality are generally poor and mud weight control is more difficult when using a starch mud.

West of the Hugoton field in western Texas County and Cimarron County, Oklahoma, and in Morton and Stanton County, Kansas, salt beds

are absent in the Permian. In this area, operators customarily set either a minimum of 13⅜-inch surface casing or no surface casing, drill to the Cimarron anhydrite at approximately 1,500 feet and set a combination surface-intermediate 8⅝-inch casing string.

Drilling fluids are dependent on the casing program. Where an intermediate casing string is set, drilling fluids are commonly chemical muds with an 8 percent-10 percent oil emulsion. The oil emulsion has been found useful in controlling mud weight and in slicking the hole to prevent sticking in the chalk section of the lower Permian and the upper Pennsylvanian.

Where the intermediate casing string has been eliminated in the casing program, the most common drilling fluid is a starch mud. Most operators prefer to keep their mud system heavily loaded with lost circulation material at all times. Cotton seed hulls in combination with one or more other commercial lost circulation sealers have been found most effective in combatting lost circulation difficulties. Close supervision of mud quality is essential at all times to insure a minimum of trouble in drilling operations.

Rigging up time runs two days or less. Drilling time varies from 15 to 30 days depending on depth. Medium rock bits are usual with 15-30 bits required per well. Footage rates vary from $4 to $5 per foot, and day rates range from $750 to $850.

Water wells approximately 300 feet deep account for the major portion of water used, but occasional hauling is required.

Crooked holes generally are not a problem, although crooked intermediate casing holes are sometimes encountered. Unless care is exercised when drilling out from intermediate casing, the whipping off of the last few joints of casing can become a serious problem.

Distance between wells renders trucking charges a major item to drilling contractors.

Completions. Cable tool completions are common throughout the area, although in some of the deeper wells in the southeastern Oklahoma Panhandle, use of pulling units and reverse circulation rotaries is not unusual.

Most operators perforate their producing zones in dry casing or with a minimum (500 feet to 600 feet) amount of load fluid. Treatment of the perforated zone, either acidizing or fracture treatment, is customarily down the casing. A packer is set on tubing while the well is dead, swabbing operations are commenced through the tubing and the well swabbed in. This same procedure, with minor variations, may be used for dual or triple completions. Production strings are usually 5½-inch casing, although some 7-inch casing is used.

Production. Proration of oil production in both Kansas and Oklahoma is based on corporation commission regulations. Oil allowables in both states are tied to depth to producing formations. The following tables illustrate the approximate present basic daily oil allowable on 40-acre spacing for the depths indicated:

Kansas

Depth of Producing Horizon	Daily Allowable in Barrels
0′-4000′	25
4000′-4500′	31
4500′-5000′	37
5000′-5500′	43
5500′-6000′	48

Oklahoma

Depth of Producing Formation	Daily Allowable in Barrels
0′-4467′	20
4467′-5000′	23
5000′-5500′	25
5500′-6000′	28
6000′-6500′	32
6500′-7000′	36
7000′-7500′	41

There are no over-all limiting gas-oil ratios for oil production in southwest Kansas and the Oklahoma Panhandle. Where such ratios are in effect, they have been established by local field rules.

Theoretical maximum gas allowables in unprorated fields in both Oklahoma and Kansas are set at 25 percent of the potential, as determined by the state, when converted to absolute open flow at the end of 24 hours. A more realistic approach to actual pipe line takes, however, is to consider minimum takes set out in contracts between producers and pipe line companies.

In most of the new contracts written for unprorated fields, the daily pipe line takes are tied to reserves. The minimum daily take in most of these new contracts is based on a daily take of 1 MMcf for a reserve figure which varies from 8 to 10 billion cubic feet. This condition has been included to satisfy Federal Power Commission requirements that no new gas contracts will be written unless the gas reserves contracted for will last at least 20 years. Take or pay clauses are being written in most new contracts.

Both flowing and pumping Pennsylvanian and Mississippian oil production is found throughout the area. Gravity of the crude oil ranges from 28 to 40.

The usual lifting equipment consists of a 1¼-inch pump connected to a gas powered prime mover. Paraffin, which is common in most Pennsylvanian oils, is counteracted by scrapers on the rod string and by internally plastic coated tubing.

Heater-treaters are used on most surface installations. Heavily wrapped flow lines and internal tank burners are winter-time heat loss preventers used to combat high pour point oil. Two hundred and 300-barrel bolted or welded steel tanks comprise normal tankage equipment. Salt water disposal is not a major problem.

The greater proportion of the produced crude is trucked from the location, even, in some cases, where oil pipe line outlets are available.

Single zone gas completions are customarily produced through tubing inside production casing with no packer. In dual completions, where neither zone is wet, a packer is set on tubing between the pays and the lower zone produced through the tubing and the upper zone through the annulus.

In some cases, triple completions have been made in 7-inch casing with three tubing strings and two packers.

—**The End**

About the Author

R. S. Buchanan is a consulting geologist and independent operator, with offices in Liberal Kan. He specializes in the subsurface geology of eastern Colorado, western Kansas, Oklahoma, north Texas panhandle and northwest New Mexico. Prior to opening his office, Buchanan was a partner in the firm of Paul, Buchanan and Marden, Consulting Geologist, for three years. His career also includes five years with United Producing Company in the Mid-Continent area.

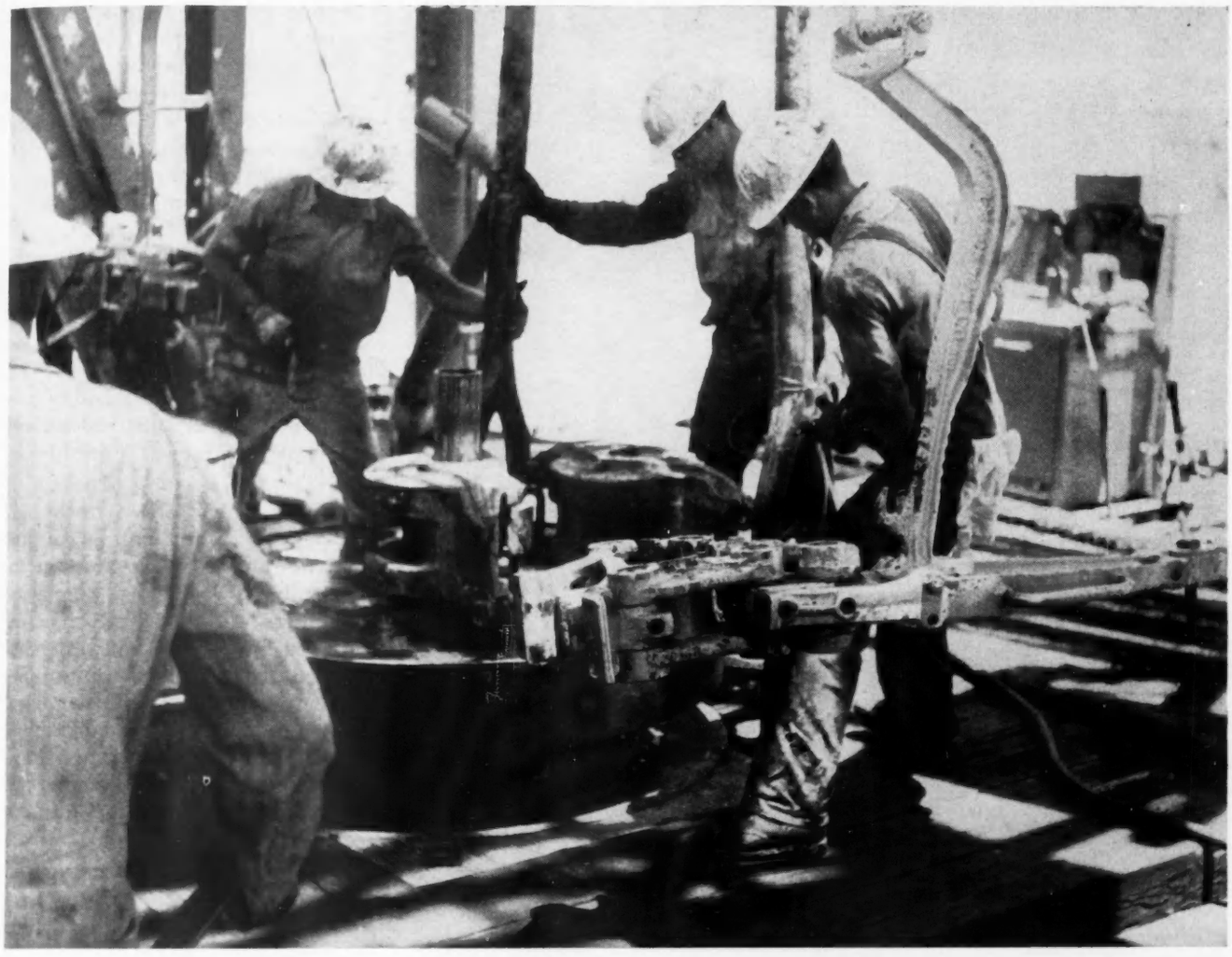


FIGURE 1—Phillips Petroleum Company uses the double elevator system illustrated to handle high strength drill pipe The first set of elevators at left center support the drill string, and rest on the elevator support table. The set of elevators at right are in position to be picked up by the elevator links which have just been detached from the first set. The procedure described is used when going in the hole. When coming out of the hole, procedure is reversed.

How to handle high strength drill pipe

New hoisting methods needed to combat notch fatigue

By J. R. Gregath
General Manager, Metal Life, Inc.
Odessa, Texas

THE INHERENT brittle quality of high strength drill pipe presents a serious problem in drilling deep wells. Premature failure or damage to this pipe, resulting from notches caused by slip dies, usually occurs in the slip area. Where the slips make contact, the pipe, when subjected to extremely heavy loads, actually surpasses its compression yield point.

The slip area fatigue problem increases with well depth, which necessitates higher strength steel. Currently, drill pipe with minimum tensile yield of 110,000 pounds is in use; however, in the near future, a minimum yield of 135,000 to possibly 150,000 pounds is anticipated. The steels used are by nature brittle because of manufacturing processes and chemistry required to attain high

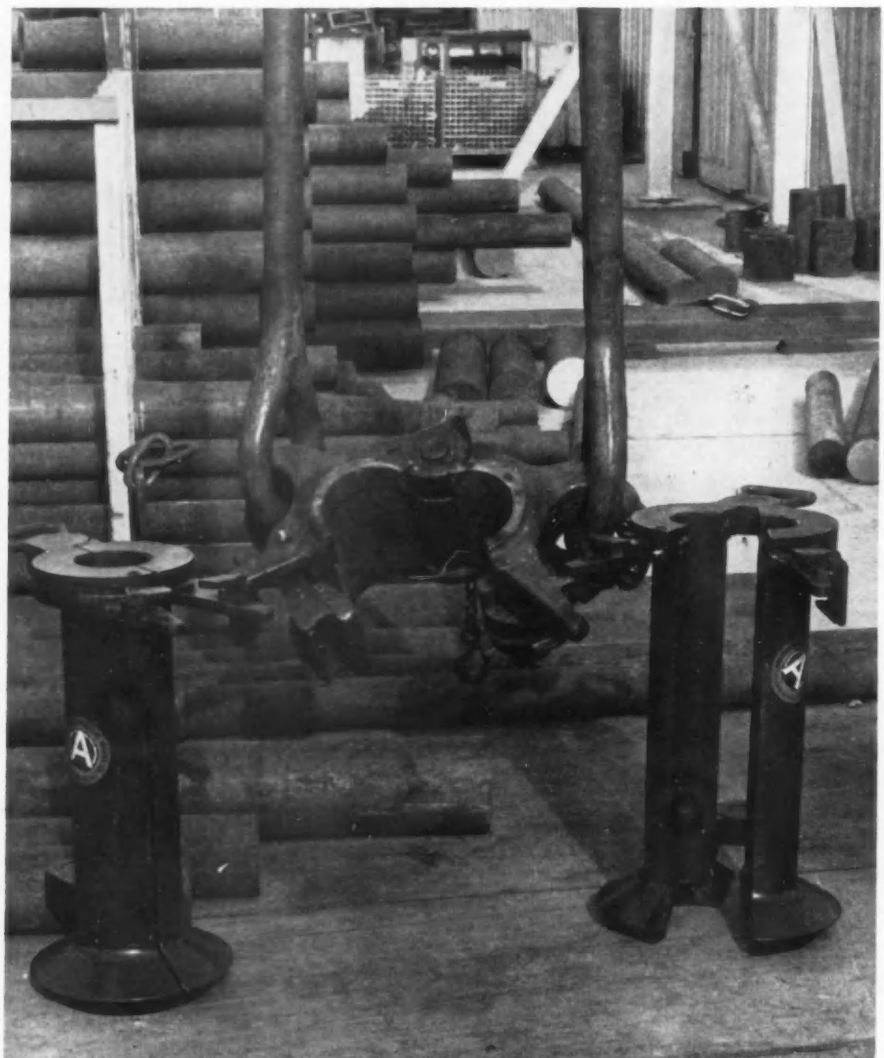


FIGURE 2—Basic equipment used in double insert system showing, left to right, split-hinged inserts; over-sized center-latch elevators; and second insert.

strength. Therefore, safe, economical and practical methods must be developed to handle the pipe.

There are two approaches in overcoming this handling problem:

- Make better use of existing tools.
- Eliminate use of slips.

The first refers to keeping the master bushings and slips dimensionally exact, and using longer slips to increase the contact area to distribute stress over a greater area (See Page 100, WORLD OIL, October 1959).

These are sound approaches in handling any drill pipe. But with what is known about notch sensitivity of high strength steel, a method which avoids notches completely would appear best. Several such systems have been developed and the advantage or disadvantage of each depends on initial cost and the length of time, if any, added to trips.

The following methods are being used or are proposed for handling high strength drill pipe:

- Double elevator system
- Double insert system
- Lifting plugs per stand of pipe
- Handling subs or elevator subs
- Double shoulder tool joint system
- Application of a plastic to the slip area.

Double elevator systems use one elevator for hoisting or lowering and another for supporting the drill string at the table (Figure 1). Equipped with quick change lock pins, elevators rest on a removable table which puts the tool joint at tong height. A slip body without dies and with inside extensions lengthened to tong height supports the drill pipe while connections are made.

This system was used on the four recent wells which were drilled below 20,000 feet. In each case, it was reasonably economical. The addition to trip time averaged about 10 seconds per stand, which was considered acceptable.

A new double elevator system featuring both automatic handling and centering of the elevators in the rotary table is being used. Centering is important in that when rotating drill pipe out of the hole, the drill pipe could damage the wellhead or the blowout preventers unless it was centered in the table. The current use of the double elevator system however, does not mean its complete acceptance or that it is the ultimate answer in handling drill pipe.

The double insert system uses an oversized, center latch elevator fitted to take a split hinged insert. (Figures 2 and 3). Two inserts are required. The same dieless slips as used with the double elevator system are used to make connections. During trips, the tool joint box rests on the top of the insert while the bottom of the insert is supported by a spider resting in the rotary table. This method requires the manual changing of the insert. While it potentially is faster than double elevators, it is more physically tiring and accident prone. However, there is less equipment expense, and the pipe is always centered.

Another possible method is the use of lifting plugs for each stand of high strength drill pipe. This system is old, well tried, but expensive and possibly accident prone. Used for years with flush joint drill pipe, lifting plugs could offer a solution in some cases if they were combined with an automatic racking and handling system on the floor and with electric motor speed wrenches to make them up and break them out.

Another proposed system is the use of handling subs or elevator subs,

About the Author

J. R. Gregath received a BS degree in mechanical engineering from the University of Kansas, in 1946. He joined Richfield Oil Corporation in California as engineering trainee and served a short period as petroleum engineer at Long Beach, Calif. In 1948 he joined Kuwait Oil Co Ltd., and served as reservoir, petroleum and drilling engineer. After a short period with Gulf Oil Corporation, Tulsa, Okla., as drilling engineer, Gregath joined Helmerich & Payne, Inc., becoming drilling superintendent for West Texas and Southern Oklahoma until 1959 when he was named general manager for Metal Life, Inc.. Odessa, Texas.

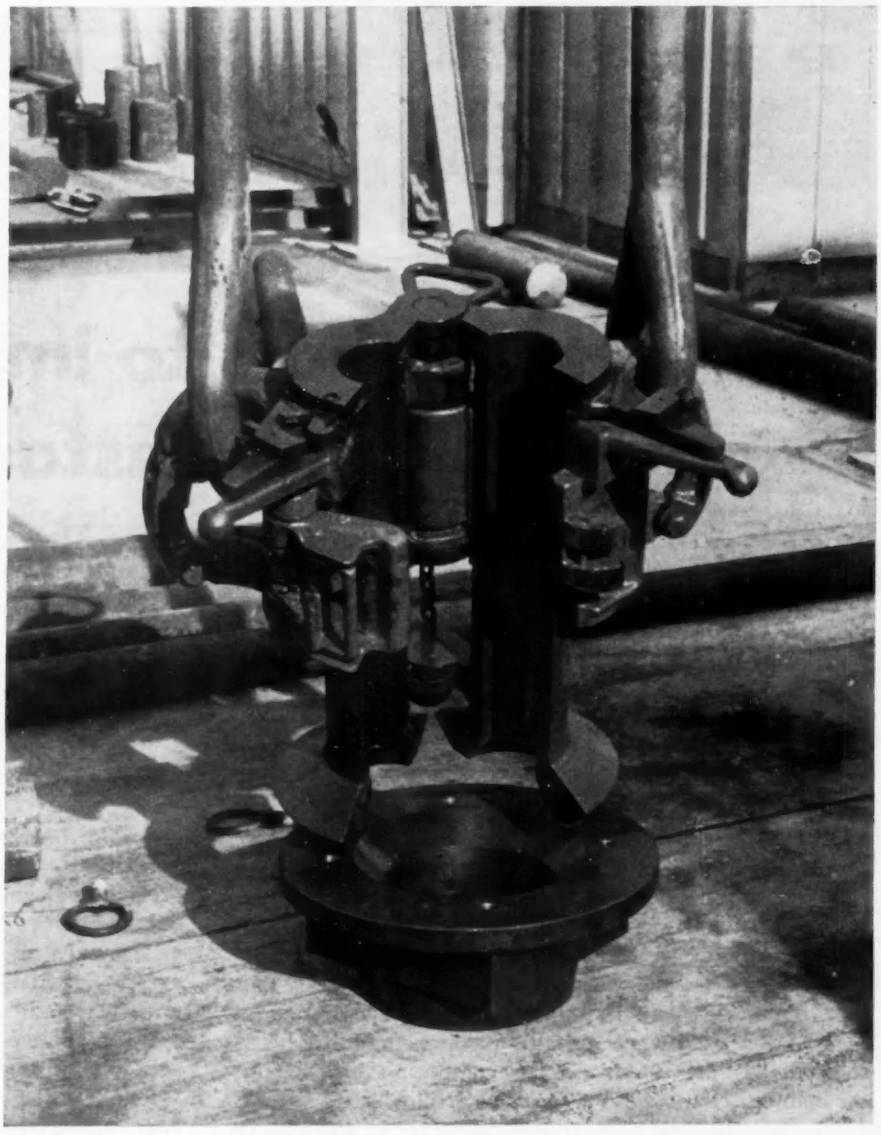


FIGURE 3—The insert in the double insert system is in the elevator ready for hoisting. The spider in which the insert rests also is shown.

with one sub per stand. These could remain in the string while drilling. Elevators would be latched on the subs, and extended slips (dieless) would catch the tool joint box and shoulders. There may be some difficulty in trip time, but it probably could be solved. The initial expense is high, and additional box and pin maintenance must be considered. There is potentially no increase in trip time. However, the method does seem to be ruled out temporarily because of the cost involved in making a sub.

In a double shoulder tool joint system, every joint — or possibly every third joint—of drill pipe could be equipped with a double shoulder tool joint. The lower shoulder would be supported by a dieless slip and the upper shoulder would rest in the elevator.

There obviously is a question of adequate support area under each shoulder. If the support area problem could be solved, the system could be used with air slips without additional accessory equipment. There is no increase in trip time.

An increase in standard tool joint OD would most likely be necessary, certainly in the 2⅞-inch or 3½-inch designs, to provide an adequate support area for both shoulders. This, in turn, would require large pin OD, possibly dictating the selection of the next larger connection size to balance the strength of the pin in the box. The resulting increase in tool joint length and mass then would be likely to produce early fatigue failure in the pipe and/or weld area. Although results of the dual elevator shock-absorber equipment have been satisfactory, safer, more efficient equipment and methods will have to be devised. Handling subs and double shouldered tool joints are considered too expensive and impractical because of the limitations on maximum OD joints and rubber protectors.

Shrinking a Grade E sleeve on the box end of internally upset drill pipe prior to flash welding the tool joints on the pipe has also been considered. This procedure would leave adequate space below the tool joint for latching the elevator, and conventional slips then would engage the sleeve rather than the high tensile drill pipe.

Considerations have also been given to applying high strength, tough plastic coating to the slip area. This coating would bear the brunt of the slip notches, and present conventional hoisting systems could then be used.

—The End

For Your PRODUCTION File

Here's how to improve your gas lift installations

PART 4: Injection gas requirements for intermittent lift

By H. W. Winkler, Engineer
Camco, Incorporated, Houston

GAS REQUIREMENTS for intermittent gas lift, which includes chamber installations and most fluid operated installations, can be calculated by several methods, but the volumetric method is believed best. These requirements are needed when selecting compressors for a closed rotative gas lift system or for computing lifting costs for comparison with other forms of artificial lift.

Intermittent lift is the displacement of a liquid slug by high-pressure gas. It is impossible to lift a liquid slug through a string of tubing by displacement with high-pressure gas without filling the tubing under the slug with gas. Therefore, operators should not expect to lift a large liquid slug from 5,000 to 10,000 feet through 2-inch or 2½-inch tubing with only a few hundred cubic feet of gas. Several articles on gas lift have indicated that a particular type of valve or type of design will result in practically no injection gas requirement. The fact is that wells given as examples are partially flowing and do not represent a dead lift application.

It is always desirable to make all calculations for field application as realistic as possible. Highly theoretical calculations based on conditions that do not exist in actual operation are useless for field work. Some literature, which illustrates gas requirement calculations by the volumetric method, is based on a minimum average pressure that experience has found to be too low. In this literature, injection gas pressure in the tubing at valve depth at the instant the slug surfaces is assumed to be equal to the pressure exerted by the slug height plus the wellhead tubing pressure and the increase in pressure due to gas column weight. Actual bomb surveys indicate this assumption to be in error.

For an operating valve with a 5/16-inch or 3/8-inch port in a typical intermittent gas lift installation, the pressure in the tubing at the depth of this valve can be assumed to be equal to the surface closing pressure of the valve at the instant the slug surfaces. This premise is reasonably accurate for most intermittent installations which are producing at least 1 to 1½ barrels per cycle through 2-inch tubing and at least 1½ to 2 barrels per cycle through 2½-inch tubing.

The pressure drop across the operating valve is assumed equal to the increase in pressure due to the weight of the gas column from the surface to the depth of the valve. The pressure in the tubing at valve depth when the slug surfaces will be less for fractional barrel slugs. However, this pressure will be much nearer the surface closing pressure of the operating valve than the pressure due to to the height of the small slug plus wellhead tubing pressure and gas column weight.

The gas required to fill the tubing under the slug should be based on an average pressure which can be calculated as follows:

$$P_{avg} = \frac{P_{us} + P_{vc} \text{ at Surf.}}{2} \qquad (6)$$

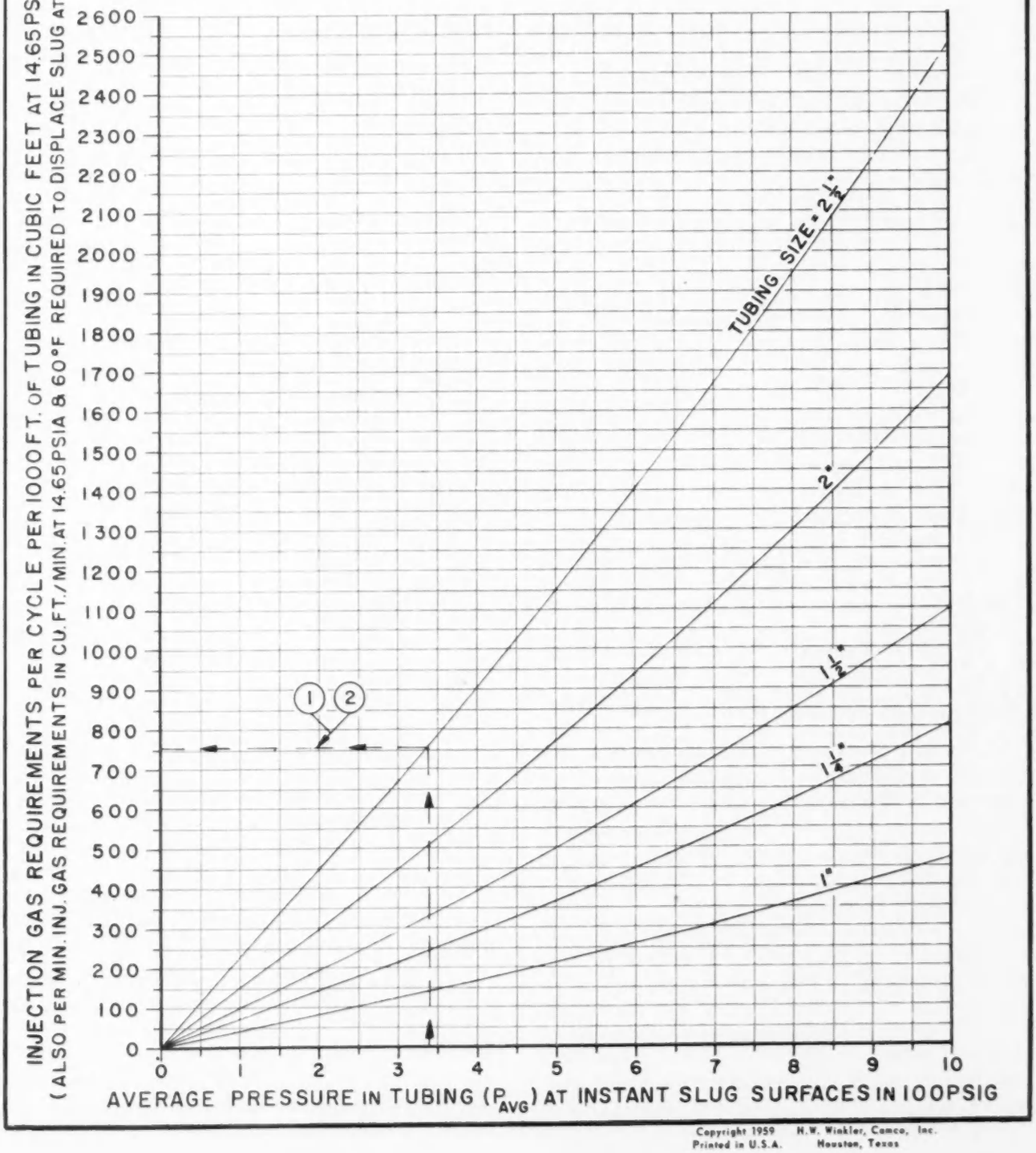
Where:

P_{us} = Pressure in tubing under slug at instant slug surfaces, psi
P_{vc} at Surf. = Closing pressure of operating valve at surface, psi

The pressure in the tubing (P_{us}) immediately under the slug at the instant the slug surfaces is equal to the pressure due to the slug height plus the wellhead tubing pressure. The liquid slug must be converted into feet of liquid in the tubing by dividing the production per cycle in barrels by the capacity of the tubing in barrels

FIGURE 7

INJECTION GAS REQUIREMENTS FOR INTERMITTENT LIFT BASED ON INJECTION GAS REQUIRED TO FILL TUBING UNDER SLUG



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per foot. Then the liquid column can be converted into pressure by multiplying the height of the liquid slug in feet by the fluid gradient in psi per foot. These calculations are based on the assumption that the slug is produced as a solid liquid column followed by dry injection gas. If the intermittent operation is representative of efficient dead lift with little formation gas, most of the liquid is produced as a solid column, and very little production results from liquid entrainment in the tail gas.

The length of tubing which must be filled with injection gas is that portion under the slug at the instant the top of the slug reaches the surface. The length of the produced slug can be subtracted from the depth of the operating valve. The decreasing pressure due to a shortening of slug height as the slug is being produced into the flow line, exceeds the decreasing pressure in the tubing due to the expansion of the injection gas in the void created by the dwindling slug length.

An equation for calculating the volume of gas in the tubing per 1,000 feet of length can be derived from the following gas law (Equation 7):

$$\frac{P_s\ (Q_s)}{Z_s\ (T_s)} = \frac{P_{avg}\ (V_t)}{Z_{avg}\ (T_{avg})} \qquad (7)$$

Solving for Q_s:

$$Q_s = \frac{P_{avg}}{Z_{avg}}\left[\frac{T_s}{T_{avg}}\right]\frac{V_t}{P_s} \qquad (8)$$

Substituting and simplifying:

$$Q_s = 0.0612\left[\frac{P_{avg}}{Z_{avg}}\right]V_t \qquad (9)$$

Where:

P_{avg} = Average pressure of gas column, psia
P_s = Standard pressure base = 14.65 psia
Q_s = Volume of gas at standard conditions, cu. ft. at 14.65 psia and 60° F.
T_{avg} = Average temperature of gas column = 580° R. (120° F.)
T_s = Standard temperature base = 520° R. (60° F.)
V_t = Capacity of tubing, cu. ft./1,000 ft.
Z_{avg} = Compressibility factor of gas at P_{avg} and T_{avg}
Z_s = Compressibility factor of gas at P_s and T_s = 1.0

The data for plotting the curves in Figure 7 were calculated using Equation 9, which is based on the assumptions noted above. Since the injection gas in the tubing under the slug is wet due to gas break-through, a gas gravity of 0.8 was assumed for determination of the compressibility factors (Z_{avg}) for the average pressures (P_{avg}) used to calculate the curves.

Figure 7 is recommended for determining the injection gas requirement for an intermittent well rather than Equation 8, because of the numerous assumptions required to solve the equation. Figure 7 also can be used to estimate on a per minute basis, the injection gas requirement necessary to displace a slug at a velocity of 1,000 feet per minute. For efficient intermittent operation, it is desirable to lift the slug at an average velocity of at least 700 to 1,000 feet per minute to minimize injection gas break-through.

The following problem example illustrates the procedure for determining the gas requirement for an intermittent well using Figure 7:

Given:

1. Tubing size = 2½-inch nominal
2. Depth of operating valve, L = 6,000 feet
3. Surface wellhead tubing pressure, P_{sw} = 40 psig
4. Daily producing rate = 48 bfpd (2.0 bbls./cycle)
5. Injection gas cycle frequency = 24 cycles/day
6. Static fluid gradient, SFG = 0.4 psi/ft.
7. Surface closing pressure of operating valve, P_{vc} = 500 psig

Find:

Injection gas-liquid ratio and daily injection gas requirement.

Solution:

1. Calculate theoretical pressure in tubing under slug (P_{su}) at instant slug surfaces:
   Height of Slug = $\frac{2.0 \text{ bbls./cycle}}{0.00579 \text{ bbls./ft.}}$ = 345 feet
   Where: Capacity of 2½-inch tubing = 0.00579 bbls./ft.
   Pressure Exerted by Slug = 345 ft. (0.4 psi/ft.) = 138 psig
   P_{su} = 40 psig + 138 psig = 178 psig
2. Calculate average pressure (P_{avg}) in tubing at instant slug surfaces using Equation 6:
   $P_{avg} = \frac{178 + 500}{2}$ = 339 psig
3. Determine volume of injection gas at standard conditions in tubing at instant slug surfaces from Figure 7 (dash line 1 and 2 on chart).
   Q_s per 1,000 feet of Tubing = 755 cu. ft./1,000 ft.
   Therefore:
   Q_s per Cycle = $\frac{755 \text{ cu. ft. } (6{,}000 \text{ ft.} - 345 \text{ ft.})}{1{,}000 \text{ ft.}}$
   = 4,270 cu. ft/cycle
4. Calculate injection gas-liquid ratio based on injection gas required to fill tubing under slug:
   Inj. GLR = $\frac{4{,}270 \text{ cu. ft./cycle}}{2 \text{ bbls./cycle}}$ = 2,135 cu. ft./bbl.
5. Calculate daily injection gas requirement based on injection gas required to fill tubing under slug:
   Daily Inj. Gas Reqmt. = 48 bbls/day (2,135 cu. ft./bbl.)
   = 102,500 cu. ft/day = 102.5 Mcfd

For the problem example above, the per minute injection gas requirement to displace the slug at a velocity of 1,000 feet per minute is 755 cubic feet per minute.

The next installment in this series will present another chart which can be used to determine injection gas requirements for wells being produced by intermittent gas lift. These gas requirements are based on the variation of injection gas pressure in the casing and the capacity of the casing annulus.

TO BE CONTINUED

Can equipment leasing cut production costs?

How does it work? Does it save money and how? Here are the answers to these questions

By C. B. Stone, Chairman of the Board
U.S. Leasing Corporation
San Francisco

THE TIGHTENING PROFIT SQUEEZE in the oil industry is leading more and more producing companies to the use of a financing tool already widespread in other industries—the leasing of capital equipment.

Millions of dollars worth of oil-producing equipment now is under lease. Major oil companies, whose rentals of real estate and tanking facilities have grown to more than a half-billion dollars a year, now are leasing production equipment, too, for much the same reason. They want to focus their cash flow more fully on the most profitable phase of their business: exploration and development.

As modern management has discovered that desks, dictaphones and delivery trucks do not themselves produce any profit, leasing of such necessary equipment has more than tripled in the past five years—to more than $1.5 billion in 1958.

To the oil industry, leasing offers even greater opportunities. This is because the potential return on additional capital is so high and because the industry's financing and management methods are already so flexible and easily adapted to new opportunities.

In industries that have taken advantage of equipment leasing, one rule of thumb is that if the needed machinery can be leased for less than the company's usual net return on working capital (an average of 18.6 percent nationally, according to Dun & Bradstreet), it should be leased. This frees money that might have been tied up in its purchase to earn its full profit for the company.

Benefits vary. The advantages of leasing will vary, of course, with each company's individual situation. But in an industry such as oil production, where profits depend more and more on the ability to capitalize on new opportunities, leasing can offer several advantages.

Take, for example, the case of a producing company whose experience is typical of many in the oil industry.

This company proved up a new development well in Ector County, Texas, but found that its lease requirements—three development wells within a year—would use up the entire $1 million annual budget provided by its non-operating partners.

The operating company had several other prospects it wanted to drill (and which would have been forfeited if not drilled). It therefore sold the tangible equipment on Well 1 to an equipment leasing company and leased it back. It then went ahead and drilled the other three wells, leasing tangible equipment for those.

First-year rental on $300,000 worth of tangible equipment was $76,500. With the $223,500 freed by the lease it drilled, the company drilled a discovery well on an-

How leasing works . . .

HERE is a dollar-and-cents example of an equipment lease made to a producing company operating in Chautauqua and Butler counties, Kansas.

Eight wells were to be drilled. All of the necessary equipment would be leased, including well equipment, tank batteries, pumping units, lead lines and a pump house.

Total Cost of Equipment:	**$201,582.14**
Length of Lease:	**Five years**
Monthly Payment:	**$4,031.64**
Deposit:	**Last three months**
Renewal:	**One month per year**

This lease has been in effect for over a year. Several of the joint-venture principals in this one producing company also are participating in other producing companies which are leasing equipment.

While this charge and payment schedule provides an example of the costs of leasing, charges will vary from company to company, depending upon credit rating, type of equipment to be leased, length of lease, frequency of lease payments and other factors.

other of its prospects. Without leasing, the operating company would have forfeited or paid the price for additional financing, if possible, on the new discovery.

How one company profited. The purchase of already-proven reserves is, of course, a common way for a producing company, provided it has the money, to maximize its profits.

The General American Oil Company of Texas, for example, managed to obtain a 100½ percent return per year on the cash investment it made in acquiring on a leveraged basis producing properties by means of reserved production payments (the so-called ABC method of financing).

In a 1958 report by Blyth and Co., General American is said to have paid $200,000 in cash and $1.8 million in reserved production payments at 5½ percent interest for one particular purchase of production. The profit factor applied as 15 percent per year in total unrecovered costs, meaning 9½ percent (15 percent less 5½ percent) on $1.8 million borrowed funds, plus 15 percent on its cash investment. Its $200,000 cash thus earned a 100½ percent annual return.

Leasing of new equipment, or a sale-leaseback of existing equipment is one way an oil-producing company can muster the cash necessary to take advantage of any attractive production-purchase opportunities.

Needless to say, leasing does not offer a magic new answer to every company's problems nor does it replace the existing standards of good business and financial practice.

What leasing does is to offer to any company—depending on its own individual position—new flexibility in its financing operations and an alternative or supplement to its existing sources of capital and credit.

Here are 11 advantages that leasing of equipment can offer to oil-producing companies . . .

1. By conserving available cash, equipment leasing lessens the need for outside financing. It avoids further splintering of ownership of new ventures; avoids dilution of company control; reduces the need for borrowing or issuing securities. An equipment lease is laid out in dollars and cents—not in production payments or percentages (see the accompanying How Leasing Works table).

2. Leasing permits the equipment user to pay for it out of future earnings. Capital is not tied up in advance in equipment that later may be useless.

3. As drilling and production costs mount through inflation and development of economically more-accessible reserves, leasing offers new flexibility in controlling such expenses.

4. If ready cash for equipment purchase is the problem, leasing offers a solution: actual dollar outlay may be less (the leasing company pays the supplier in cash, obtaining—and passing on to the lessee—the sometimes substantial savings available for cash terms).

Leasing requires less than half as much initial payment as a conditional sale contract, and, in contrast to bank credit, 100 percent of the purchase price is covered by a lease arrangement.

5. Leasing is an additional credit source. A company with established credit can "shop around" more, and actually enlarge its borrowing capacity without disturbing its existing lines of credit.

6. Leasing improves balance sheet ratios. In situations where further capital expenditures would bulk too large as liabilities, an equipment lease, which does not appear as a liability, may be the answer.

7. Leasing can provide a hedge against obsolescence. The increased efficiency of new machinery can, as a rule, more than offset the cost of leasing new machinery. Recovery of capital investment through depreciation generally is insufficient to replace equipment when it becomes obsolete, with consequently high operating and maintenance costs.

8. Continuing inflation makes leasing attractive to companies that prefer to pay for today's goods with tomorrow's dollars.

9. In some cases, leases offer a real saving in bookkeeping time, effort and expense. One rental check can be written for a lease covering unrelated items of equipment having different useful lives for depreciation purposes. Different capital accounts and depreciation schedules can be eliminated.

10. The entire cost of equipment used to carry out a specific contract can be concentrated, under a lease, into the basic lease period and working contract. This practice, often applied to government contracts, could be used by drilling contractors working for oil companies overseas, foreign governments or foreign companies.

11. Leasing can save taxes. In an industry so intimately concerned with taxes as oil production, it would be unwise to discuss anything but specific individual cases. One basic fact: rentals paid under an equipment lease usually are fully deductible.

Whether a specific lease offers new tax advantages to a company in terms of tax reduction or deferral must be weighed, along with other considerations, while considering a lease. In any case, the flexibility and alternatives offered by equipment leasing are worth consideration.

Preventing equipment failure in sour gas-condensate wells

Evaluation program, proper selection of materials and appropriate completion practices will minimize wellhead, down-hole damage caused by H_2S stress corrosion cracking

By Keith N. Wallam, Chemical Engineer
and Vincent P. Milo, Chemical Engineer
Shell Oil Company of Canada, Ltd., Calgary, Alta.

SHELL OIL COMPANY OF CANADA, LIMITED, has experienced a severe hydrogen sulfide stress corrosion cracking problem in producing sour gas-condensate wells in Alberta. Similar conditions have been found in sour gas fields of the United States. As a result of extensive field and laboratory study, producing equipment material failure due to stress corrosion cracking has been reduced to a minimum. Shell now applies the following measures in sour gas-condensate producing areas:

- Well equipment exposed to the sour gas stream is constructed of especially selected corrosive resistant metals.
- Field tests are conducted in each newly discovered field to determine the severity of the problem.
- The water cushion used in drill-stem testing operations is inhibited with a water soluble organic corrosion inhibitor. Drill pipe contact time with the sour gas is reduced to a minimum.
- To protect casing strings, wells are completed with a high Ph mud in the casing-tubing annulus. This fluid is displaced with oil containing oil soluble organic inhibitor after the final tubing trip.
- To prevent tubing failures, a regular stick inhibition schedule is used. When a well is shut in for an extended period, the tubing is plugged and loaded with inhibited oil.
- Subsurface wire line equipment is soaked with inhibitor before running in the hole.

Hydrogen sulfide stress corrosion cracking became a serious problem following discovery of the Pincher Creek and Jumping Pound sour gas-condensate fields. Early in the lives of these fields, spontaneous failure of well equipment occurred without any apparent cause, and with little warning. Similar failures occurred in scattered fields throughout the United States. The severity of the problem was accentuated by the economic and personnel hazards inherent in the failure of equipment in wells handling high pressure, poisonous sulfide gases. Extensive laboratory and field work was undertaken to solve the problem, by both operating companies and NACE Technical Unit Committee T-1G.

As a result of these studies, much has been learned about hydrogen sulfide stress corrosion cracking. The results of these research programs have been published.[1,3] This article outlines Shell's experience in Canada and discusses, from a practical point of view, the precautionary measures

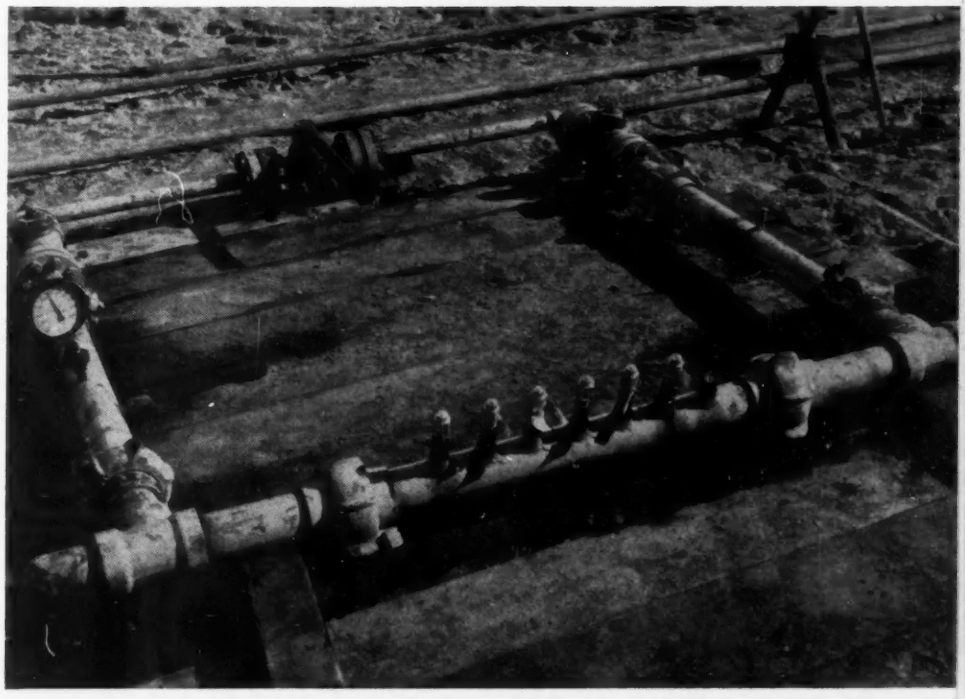


FIGURE 1—This portable test bypass is used to determine the susceptibility of different alloys to hydrogen sulfide stress corrosion cracking. The bypass is installed on the well flow line and the well stream is directed through the leg containing the test samples.

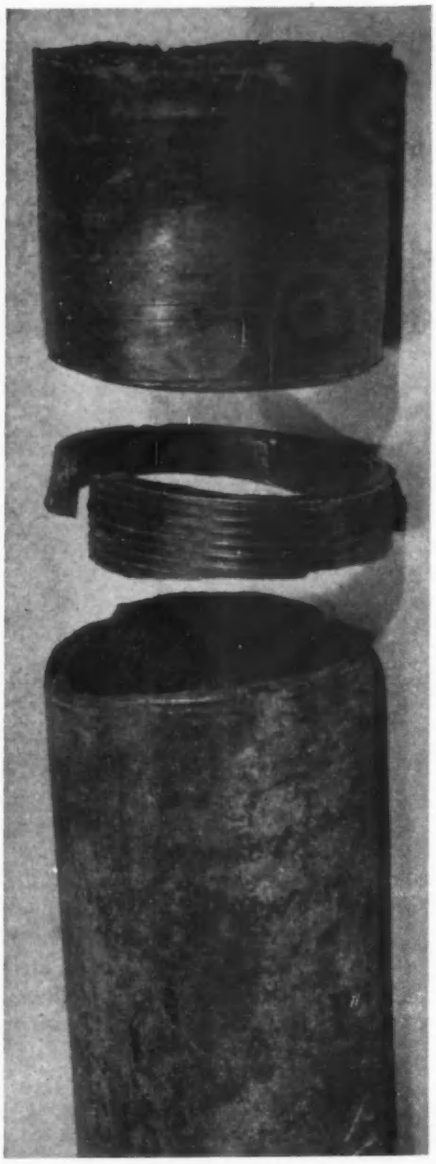


FIGURE 2—Here is an example of casing failure due to H_2S stress corrosion cracking. This sample of 5-inch N-80 pipe was recovered from a well completed with chromate inhibited mud.

taken to reduce the danger of material failure in sour gas-condensate production operations.

General considerations for stress cracking. The presence of hydrogen sulfide induces spontaneous failure of metals. It has been shown:

1. In a given environment and at a given stress level, the susceptibility of materials to sulfide corrosion cracking varies widely.

2. Environments vary widely in their ability to cause sulfide corrosion cracking in a given material at a given stress level.

3. The probability that a given material will fail in a given environment increases as the stress increases.

4. Since the production of hydrogen by the corrosion of the material is a prerequisite to cracking, methods which prevent corrosion may be expected to prevent cracking.

Generally, Shell's program has been to evaluate the severity of the environment by means of field tests, and then reduce the probability of failure to a minimum by proper selection of materials and design.

Evaluation and well tests. Test methods used are based on those developed by Shell Development Company.[2] Specimens of selected alloys of known susceptibility are stressed to 120,000 psi extreme fiber stress by loading as a simple beam. They then are exposed to the unknown environment as early in the life of the field as possible. Often, this will be during testing of the first well in the field. Alloys used in the field test are graded as to their relative susceptibilities in a standard severe laboratory environment. Table 1 shows a list of materials with their relative susceptibilities. By statistical analysis of the failure experience during the test, a numerical comparison of the new environment to the standard environment can be made. This in turn provides an indication of which materials may be suitable for service in the new environment.

In addition to the cracking tests attempts also are made to evaluate the potential weight loss problem through use of weight loss coupons and rate-of-corrosion meter probes. For this purpose, special high pressure probes of J-55 and N-80 tubing steel are used. Figure 1 shows a flowline bypass used in these tests.

Table 2 lists the severity of sulfide corrosion cracking in some of the environments where tests were run. The standard laboratory environment has a relative susceptibility R_s of 12 on the S_c scale. The higher the R_s value the more severe the environment. It can be seen from Table 2 that there is no apparent correlation between the hydrogen sulfide content of the environment and its severity.

Stress cracking failures during DST. Shell has had only one serious failure during drillstem testing operations that can be attributed definitely to sulfide corrosion cracking. In February 1958 a successful test was conducted at a depth of 9,000 feet in Panther River 1 well. As is customary, sufficient water cushion was run to prevent collapse of the pipe. Following the test, the packer would not come loose. After jarring several times, the pipe parted at a hook load of 50,000 pounds over the weight of the string. This load was well below the yield limit of the pipe. Due to a combination of circumstances the drill pipe had been exposed to sour gas for not less than 10 hours. Five tool joint failures (two pins and three boxes) occurred. The tool joints were manufactured according to AISI specification 4135 and flash welded to API Grade E pipe. Calculations indicate that the probable susceptibility of 4135 steel to sulfide cracking is fairly high, depending on the best treatment and hardness.

In the future, the water cushion used in drillstem tests will be inhibited with a water soluble organic corrosion inhibitor and every precaution will be taken to reduce the contact time with the sour gas.

TABLE 1—Here are relative susceptibilities of some materials to sulfide corrosion cracking.

ALLOY	TREATMENT	S_c*
9 Ni		0.6—2.0
SAE 4340	hardened	2.1
5 Ni		2.7
12 Cr	wrought	4.0
P-110		4.3
12 Cr	heat treated	5.6
N-80	normalized	6.1
N-80	tempered	9.6
J-55		11.2
N-80	Low moly heat treated	14.1

Additional alloys in which no cracking occurred under severe laboratory conditions.
monel, K-monel
300 Series stainless steels

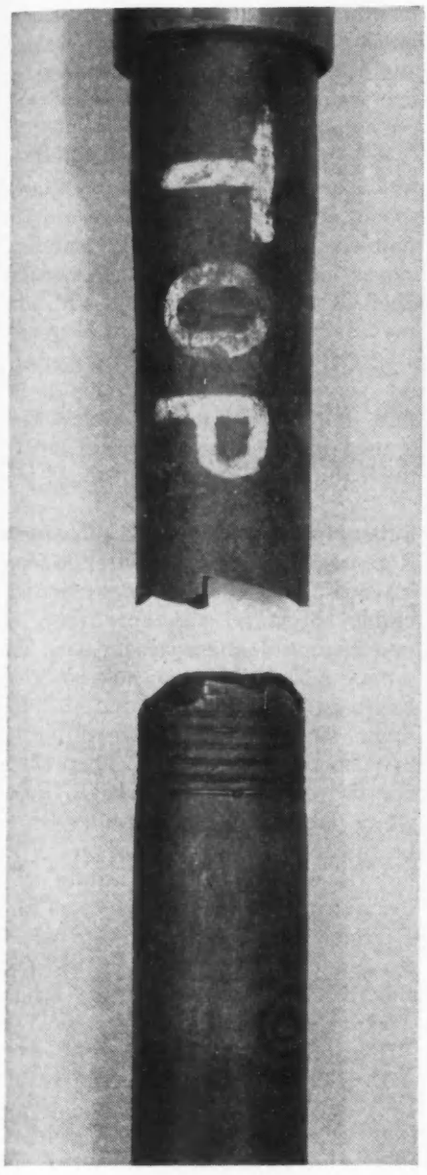
* Stress in pound per square inch (divided by 10,000) at which a given material has a 50 percent probability of failure in a standard laboratory environment.

Casing failures. A casing failure occurred in a well in the Okotoks field

TABLE 2—Tests were run to determine the severity of sulfide corrosion cracking in these six fields. Note that there is no apparent correlation between H_2S content and severity of corrosion.

Environment	% H_2S	R_s Severity	Remarks
Okotoks pilot plant	35	5.1	Water saturated with gas @ 500 p.s.i.
Jumping Pound field	3.5	4.4	Normal production
Okotoks field	35	1.1	Normal production
Waterton field	33	1.4*	Normal production
Sarcee	3.7	0.8*	Normal production
Crossfield	0.4	2.3	Normal production

* These represent the S_c values of the most susceptible alloy in the test. No failures occurred.



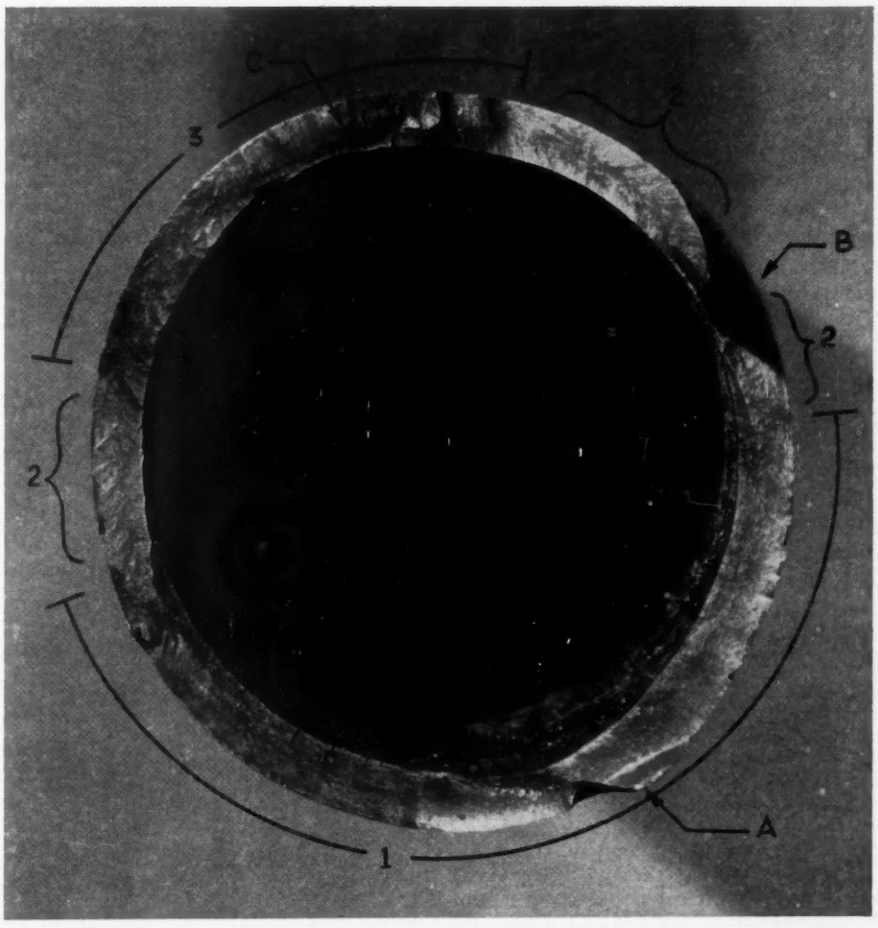


FIGURE 4—Fracture face details of the tubing shown in Figure 3 are apparent here. Note feathery markings in regions marked "2". Shear on a 45-degree plane occurred on half marked "1" with distinct plastic deformation visible near point A. Fracture in region marked "3" has both ductile and brittle characteristics.

FIGURE 3—This joint of N-80 tubing (left) failed after being exposed only for the duration of a short open-flow potential test. No protective measures had been taken Slip marks on the lower section were caused by fishing tools used to recover the string.

completed with 5-inch N-80 casing. The well was completed with chromate inhibited mud in the tubing casing annulus (½ lb/bbl), and shut-in. During a later workover to install a hot-oil circulating string for hydrate control, the casing was found to be parted as shown in Figure 2. This type of failure is typical of sulfide corrosion cracking.

Crown Okotoks 1 was completed by Shell in April 1953 as a shut-in Devonian sour gas well. In August 1954 the well was produced for 67 days to the sulfur recovery pilot plant and then shut-in. Shell subsequently sold its Okotoks wells.

In March 1958 the new operator attempted to work over the Crown well and discovered that 2,300 feet of the 3,100 foot circulating string had dropped to bottom. Although sour gas does not normally come in contact with the circulating string, a tubing leak had developed during the shut-in period allowing the gas to enter the tubing-casing annulus.

Pipe was recovered, new tubular goods were run and the well recompleted. After approximately 70 percent of the spent acid following acid treatment had been recovered, the well was shut-in for 76 hours. During this time the tubing and circulating string both failed. All collars on the five-inch casing and at least three tubing collars cracked longitudinally with no deformation of the steel. In addition to the collars splitting, 250 feet of the five-inch casing telescoped when the pipe dropped. These failures resulted in the subsequent abandonment of the well.

A metallurgical examination of recovered pipe indicated the casing was probably coupled with N-80 collars and the new tubing was probably down-graded N-80 pipe. Such material would be expected to fail due to sulfide stress cracking in the Okotoks gas environment, and would explain the failures encountered.

To guard against casing corrosion attack, wells usually are completed with the casing filled with high pH mud. After the final tubing trip, the annular fluid is displaced with oil inhibited with 1/10 of one percent of oil soluble organic inhibitor. Should a tubing leak develop and the fluid level in the annulus drop, the casing annulus is either filled with inhibited oil, or injection of a volatile aliphatic amine, such as diethylamine, is commenced.

Tubing failures. Initially, wells in the Jumping Pound field were completed with N-80 tubing and two failures occurred. Both of these were

attributed to sulfide corrosion cracking. The first failure was observed after the well was shut-in following a short open-flow potential test. No attempt had been made to protect the tubing from corrosion. The failure occurred at a depth of 1,430 feet. At that point, tubing stresses were approximately 25,000 psi in longitudinal tension and 15,000 psi in hoop tension. Figures 3 and 4 show views of this failure. Subsequent laboratory tests indicated this N-80 material to be susceptible to sulfide cracking.

The second failure occurred in another well which had produced for two years. The failure appeared to be the same type as experienced previously. However, in this well the N-80 tubing had been internally coated with a baked phenolic enamel, which later was found to be only two mils thick at the point of failure. Also, there was some local hardening at the point of failure. Failure occurred at a depth of 6,100 feet, where tubing stresses were approximately 10,000 psi in longitudinal tension. Stick inhibition was being used on this well at the time of the failure.

Two other wells that had been completed with uncoated N-80 tubing were put on a regular stick inhibition schedule when placed on production. Subsequent wells were completed with J-55 tubing, a material that laboratory tests indicated as having low susceptibility to sulfide stress corrosion cracking. Although J-55 tubing was used, subsequent investigation indicated that collars may be N-80, so stick inhibition of all Jumping Pound wells was instituted. Since July 1953, the wells in the Jumping Pound field have been produced without further tubing failures.

Currently, the completion program for sour gas wells utilizes 2½ inch, J-55 tubing, which is adequate in tension to 9,600 feet. Laboratory work indicated that tempering low molybdenum N-80 tubing at 1,100° F for ½ hour will reduce its susceptibility to sulfide cracking to that of J-55 material. This special material is used at depths where N-80 tubing is required. To date a method of reducing the susceptibility of P-105 alloys has not been found. Tubing strings of heavy wall J-55 and heat-treated N-80 alloys have been designed for use at depths where P-105 material would normally be required to maintain desired safety factors in tension.

With the exception of Jumping Pound, where N-80 tubing and collars were used, environmental evaluation tests indicate that inhibition is not required in any wells where J-55 or special tempered N-80 tubing is used. Wells in fields such as Okotoks, Waterton, Sarcee and Crossfield have been flowed on extensive production tests without inhibition, and without evidence of damage. When a well is shut in for an extended period, the tubing is plugged and then loaded with inhibited oil.

Wellheads and valves. The only failures of this type were encountered early in the lives of the sour gas fields. Among the valve parts that failed were stems and springs. The failed parts were usually manufactured from 12 chrome steel (400 series stainless); however, Shell now specifies K-monel for this service. In the early 1950's some gate valve bodies were welded and occasional failures occurred at the welds. This difficulty has been remedied by casting the valve bodies.

Present practice is to use standard wellhead alloys for flanges, bowls, spools, etc. Flange ring gaskets are 316 stainless steel. Although standard valves have been used successfully, Shell is currently working with the manufactures in an attempt to obtain a special trim valve for hydrogen sulfide service. An effort is made to insure that no 400 series stainless steel is used in the manufacture of any of this equipment.

Subsurface wire line equipment. Recently, Shell and the wireline service companies have directed considerable effort to the selection of non-susceptible materials for wire line service tools and bottom hole controls. Frequent failures occurred in the single strand wire lines used in the first few sour gas wells. These lines are drawn from high-strength steels which laboratory tests have shown to be susceptible to stress cracking. Two failures occurred in the fishing neck of one type of downhole wireline tool. Examination showed they were caused by sulfide corrosion cracking and that the material from which the fishing necks were manufactured was 17-4 PH stainless steel, a susceptible alloy.

Currently, all wireline tools for use by Shell in Canada will be made of 300 series stainless steel, aluminum, and other non-susceptible alloys. Locator keys will be manufactured from 8620 steel. Although 8620 steel is expected to be susceptible, these keys are not expected to be highly stressed. Service tools, wireline, jars, etc. are still manufactured from high strength susceptible steels. At present, because of mechanical requirements, these tools cannot be made from non-susceptible materials. Therefore, prior to running in the hole, the wireline and all service tools are soaked with an organic corrosion inhibitor. Coating the wireline with inhibitor in this manner has prevented stress cracking failures over the past five years.

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Keith N. Wallam has been employed in the Mechanical Engineering Section of Shell Oil Company of Canada, Limited's Exploration and Production Department since January 1954. He is responsible for those chemical engineering and corrosion problems, in his division, associated with the production of oil and natural gas. He is an honor chemical engineering graduate of Longborough College of Technology, England, a graduate member of the Institution of Chemical Engineers, London, and a registered professional engineer in Alberta, Canada.

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How to improve LACT performance

New integrated instrumentation package provides complete data readout system, allows 30 day unattended lease operation

By Louis E. Kuntz
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RECENTLY DEVELOPED TECHNIQUES have increased the effectiveness of Lease Automatic Custody Transfer instrumentation. An integrated packaged unit composed of a BS&W monitor, integrator, gravity transducer and temperature transducer has been designed especially for LACT operations. The instrumentation package forms a complete data readout system for 30 day unattended lease operation, provides savings in labor, eliminates sample storage and prevents losses associated with manual techniques of determining BS&W content and API gravity.

In new oil fields, newly formed secondary recovery units, and on leases where at least 200 bopd are transferred from storage to pipe line, Lease Automatic Custody Transfer (LACT) is more efficient and economical than manual custody transfer.

When LACT was accepted by producers and pipe lines, commercially available instruments and equipment were adopted to automate manual transfer procedures. From an instrumentation standpoint, however, there was considerable room for improvement, since operators found that some manual attention was required to keep some systems in operation.

Most difficulties occurred in level controls, recording instruments, product sampling and data handling at the lease. It was obvious that true unattended lease operation could best be achieved by instruments and equipment designed specifically for LACT operations. This article describes new instrumentation developed for this purpose. All equipment discussed is applicable to both dump tank and PD meter LACT systems.

BS&W MONITOR

A very accurate BS&W monitoring system has been used successfully by the author. This instrument, calibrated 0—2 percent BS&W full scale, will measure contamination to ± 0.02 percent and has measuring circuit resolution of ± 0.01 percent. It is suited to oil field service having built-in test means.

This allows nontechnical personnel to check calibration and sensitivity, and perform electronic realignment required as a result of vacuum tube replacement. The indicating meter relay is calibrated directly in tenths of a percent BS&W, and has an adjustable upper contact. The instrument is "fail-safe" in the event of tube failure or malfunction of the measuring circuit.

Special circuit and sample cell design make the instrument stable, even at high sensitivity, on leases where line voltage varies ± 15 percent, and

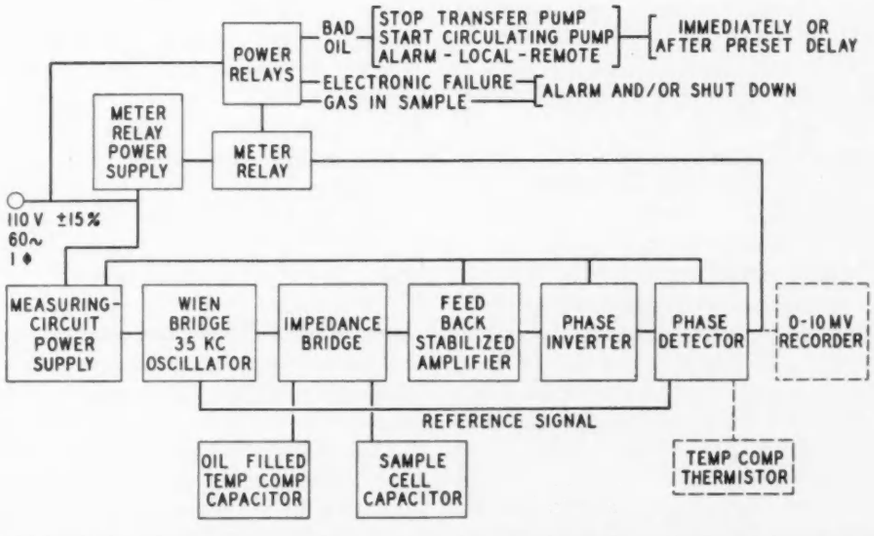


FIGURE 1—Here is the capacitance measuring circuit for the BS&W monitor. Temperature compensation is achieved through an oil filled capacitor or a probe mounted thermistor.

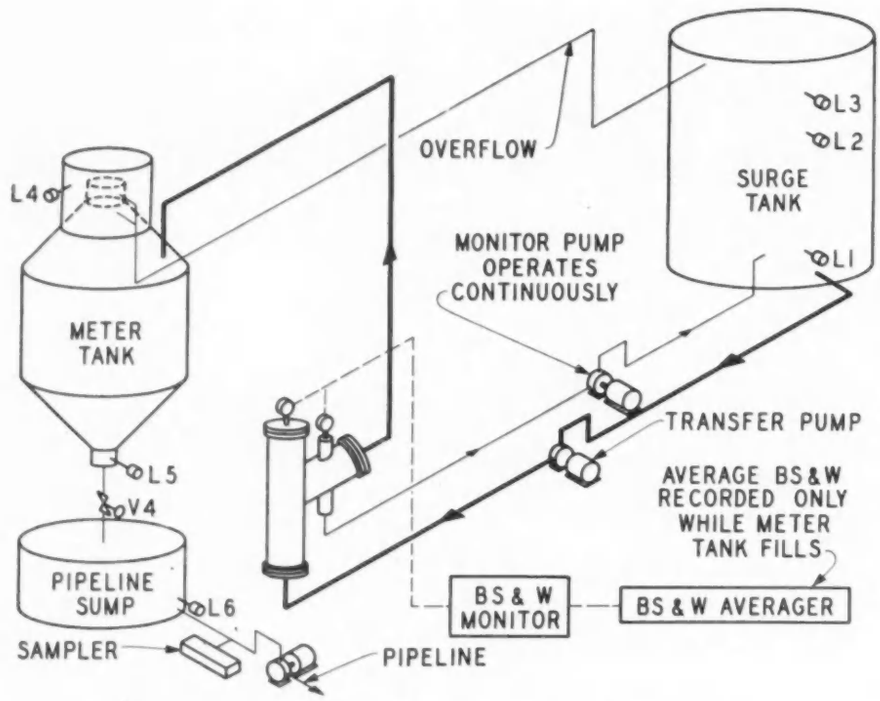


FIGURE 2—The BS&W monitor can be mounted on a fixed volume tank LACT system to sample a side stream from the surge tank and also sample the total transferred stream when the meter tank is being filled. The installation also is applicable to a PD meter system.

contamination in the fluid varies widely in type and quantity.

Dry crude oil dielectric constants range from 2 to 2.3 while water has a dielectric constant of about 80. The dielectric constant of a water-in-oil emulsion increases approximately 3 percent for each one percent (by volume) of water content. This relationship is practically linear up to 50 percent water. Tests show that most sedimentary contaminants in crude oil have an affinity for water and, being wet, cause nearly the same dielectric change.

The dielectric constant of crude oil decreases approximately 0.8 percent for each 10° F temperature rise. Therefore, temperature compensation is required for accurate BS&W measurement.

Capacitance measuring circuit. The capacitance measuring circuit for the BS&W monitor is shown in Figure 1. A fixed frequency (35KC) Wien bridge oscillator drives a precision impedance bridge. One arm of the impedance bridge includes the sample cell capacitor. The bridge configuration is such that unbalance signals resulting from resistance or capacitance are approximately 90° out of phase with respect to each other. The unbalance signal is amplified and shifted in phase so that capacitance signals arrive in phase, or 180° out of phase, with a reference signal derived from the driving oscillator. The resistive signal thus is about 90° out of phase with the reference signal.

The phase detector produces no output signal since it is relatively insensitive to the resistive signal and does not detect changes in the leakage characteristics of the sample cell and its fluid. The resultant output signal is proportional only to the magnitude and direction of the dielectric constant change in the liquid stream.

The output of the phase detector is monitored by a meter relay which has adjustable upper and lower limit contacts and associated power circuitry to perform control functions.

Temperature compensation. The oil filled temperature compensation capacitor performs this function. This reference cell has the same active capacity as the sample cell and is filled with dry crude representative of that transferred. It is connected to the impedance bridge electrically opposite the sample cell and is mounted physically in the flowing stream so that temperatures are equal. Temperature caused variations in fluid dielectric constant will cause equal impedance changes and no unbalance signal will result.

An alternate method of temperature compensation (dashed lines, Figure 1) uses a probe-mounted thermistor immersed in the sample stream and connected electrically to the phase detector.

Sample cell. Sample cell design can be simple or complicated, depending on application. Concentric cylinder electrodes are the most practical for measuring fluid dielectric constants. When the fluid contains no contaminants which adhere to the cell elements, a simple spool mounted directly in the line is sufficient.

Where paraffin, wax and sludge tend to "build-up" on the measuring elements, a tee configuration can be used which allows the center electrode to be removed for cleaning. Plastic coating or hard-chroming of the cell elements helps to prevent build-up. High velocity turbulent flow through the cell also provides cleaning action. If the cell is sized so that it restricts the line slightly, velocity will be increased. There should be no restrictions (pressure drop) ahead of the cell that might cause gas to break out of solution.

AUTOMATIC AVERAGING BS&W

Figure 2 shows a piping arrangement which allows the monitor to continuously sample a side stream from the surge tank and also sample the total transferred stream when the meter tank is being filled. A similar arrangement can be used in a PD meter system.

Since the transfer rate through the sample cell is essentially constant, the monitor reading integrated with respect to time will give the percent volume of BS&W transferred. A summation of instantaneous monitor readings over a period of time from T_1 to T_2 divided by time $T_2 - T_1$, will give the average percent BS&W transferred during the period regardless of the absolute flow rate so long as it is constant.

An "averager" has been developed which receives the monitor DC voltage output and converts it to a pulse rate in the following manner:

DC voltage from the monitor is applied to a saturable core reactor

through a transistorized switching circuit. Direct current in the winding causes core saturation in the positive direction at which instant the polarity of the coil input is reversed by action of the transistors. The core then is driven to negative saturation and switching again occurs. The saturation and switching rate are directly proportional to the magnitude of the DC voltage from the BS&W monitor. Each switching operation pulses the averager output relay.

Pulse rate variation is linear from 0 to 100 pulses per minute corresponding to the monitor output for 0 to 1 percent BS&W. While the transfer pump is running, BS&W pulses accumulate on an electrical impulse counter, and time is registered in hundredths of minutes on a digital clock. At any instant, the average percent BS&W transferred (since the registers were set to zero) is the quotient of the BS&W register divided by the time register. The averager is constructed of static components except for the pulsing relay which is a mercury-wetted contact type.

Prime considerations in this automatic system are the increased accuracy of analyzing the stream, elimination of sample storage and elimination of human error in sample and data handling. Over-all accuracy of the monitor and averager is plus or minus 0.02 percent BS&W. Centrifuged composite samples cannot be read with such accuracy.

In the manual method, any small error in obtaining crude samples from the transfer line and from the sample storage container is magnified in direct proportion to the volume of oil transferred. In most instances the 50 cc sample represents at least 500 barrels of oil and in some cases as much as 10,000 barrels. When the monitor is used, every drop of the fluid is analyzed for BS & W content during the exact time of transfer—there is no draw off of a side stream or intermediate storage for later analysis.

GRAVITY AND TEMPERATURE INSTRUMENTATION

The monitor—full flow cell—averager combination provides a continuous stream analysis whose average value can be accumulated over any period of time. Most operators would replace daily or weekly run tickets with monthly accounting if complete data—average gravity, average temperature, average BS&W—could be accumulated accurately and stored over that period. With this in mind, gravity and temperature sensing devices have been developed specifically for LACT.

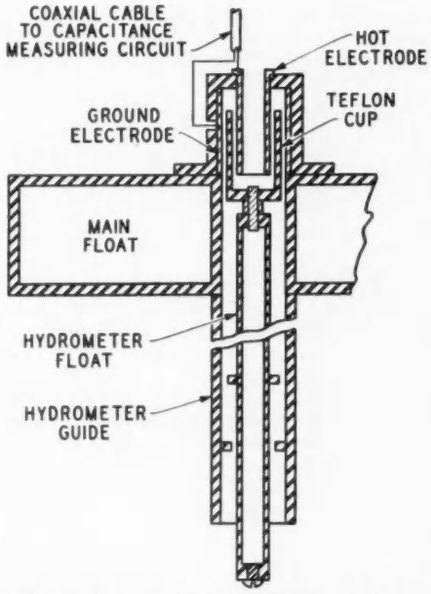


FIGURE 3 — This gravity capacitance transducer converts API gravity to capacitance, which in turn is sensed by the BS&W monitor measuring circuit.

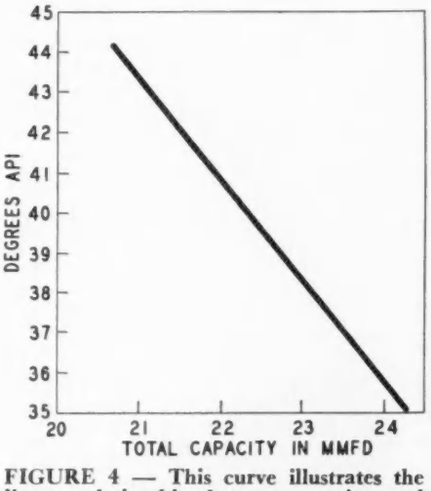


FIGURE 4 — This curve illustrates the linear relationship between gravity and capacitance change for a typical transducer.

This equipment can be time shared with the average and/or BS&W monitor by means of a simple programer. Gravity transducers are being field tested and show promise of success. The temperature transducer has operated without difficulty since installation and has been accepted for field use.

Gravity-differential pressure transducer. This device computes API gravity of the fluid by measuring the hydrostatic head developed in the metering tank. A conventional differential pressure transducer is used to convert pressure into an electrical signal. The computer receives this signal and obtains the corresponding value for gravity in degrees API.

The instrument is designed to operate at differential pressures between 57 and 75 inches of water. Accuracy of the instrument is better than 0.1 degree API. Magnetic amplifiers, transistors and silicon diodes are used in the computer. It contains no vacuum tubes or moving parts.

The output of the gravity computer is applied to the averager for one minute each time the meter tank is filled to the weir level and causes zero to 100 pulses per minute output for a gravity range of 35 to 45 degrees—each pulse represents 0.1 degree. Total pulses registered during a period of time divided by the number of tank dumps occurring in this same period, gives the average *change* in gravity (in tenths of degrees) which must be added to 35 to obtain the absolute value of average API gravity.

Gravity capacitance transducer. Figure 3 illustrates a transducer for converting gravity to capacitance which in turn is sensed by the BS&W monitor measuring circuit. The complete unit is installed in the meter tank dome. A sheet metal enclosure provides protection from condensate and supports the unit a few inches below the weir level when the tank is empty. When the tank fills, the capacitor unit is supported by the main float which floats freely on the oil surface. The hydrometer float is independent of the main float and is designed so that a 10 degree gravity change will cause it to move up and down approximately 2 inches with respect to the main float. The teflon cup attached to the upper end of the hydrometer float moves in and out between the stainless steel concentric cylinders comprising the capacitor. The change in capacitance caused by movement of the teflon cup between cylinders is measured by the same capacitance instrument that is used for BS&W.

The capacitor, teflon cup and hydrometer float are designed so that the capacitance change caused by the hy-

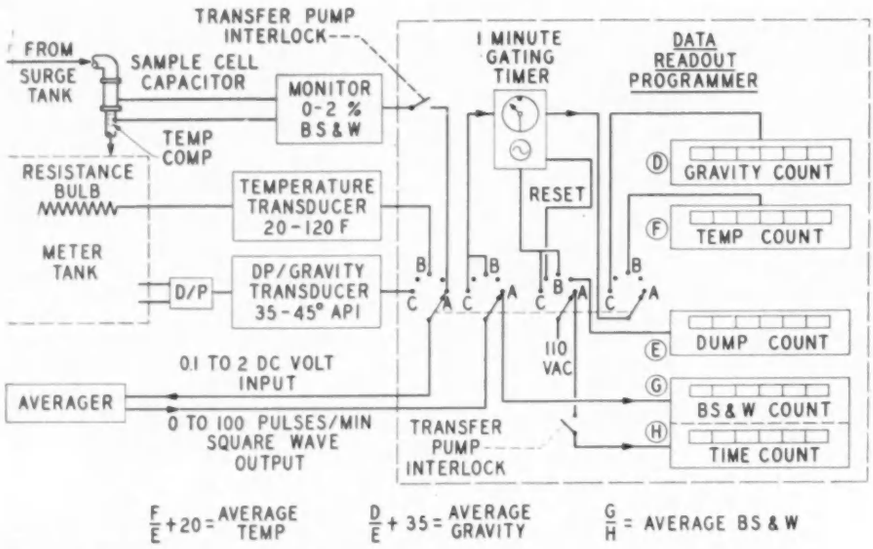


FIGURE 5—Here is a complete data readout system for LACT. The programer controls the readout sequence in step with the filling and dumping of the meter tank.

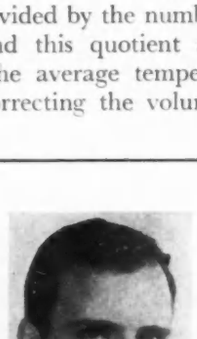
drometer movement will fall on-scale for the monitor calibrated 0 - 2 percent BS&W in the BS&W cell. Figure 4 shows the linear relationship between oil gravity and capacitance change for a typical transducer.

The gravity readout requires only one minute during the time the meter tank is filled to weir level. The gravity cell is substituted automatically for the BS&W cell during the interval and readout is accomplished in much the same fashion as described previously. In this case however, the pulse rate is inversely proportional to API gravity because the hydrometer float is buoyed most by the lower gravity fluid.

Temperature unit. The temperature sensing unit consists of a power supply, magnetic amplifier and scale factor unit on a common chassis. A platinum wire resistance bulb housed in a stainless steel tube is used to sense the temperature change in the meter tank. Two adjustable dials provide for zero and span settings. There are no vacuum tubes in the system and the output is normally zero to one milliampere into 1,500 ohms—linear with temperature. A panel mounted meter continuously indicates temperature in degrees F.

In this application, the temperature transducer output is applied automatically to the averager when the meter tank is filled to the weir level —just prior to the gravity readout. The averager output is zero to 100 pulses per minute which is directly proportional to 20° to 120° F. Each pulse accumulated during the one minute gaging time represents one degree F above the base value of 20° F.

Average temperature for a given period of time will be the total pulses divided by the number of tank dumps and this quotient added to 20° F. The average temperature is used in correcting the volume to 60° F and also in correcting average "observed" gravity to gravity at 60° F.



About the Author

L. E. Kuntz was graduated from the University of Nebraska in 1951 with a B.S. degree in electrical engineering. From 1951 until 1954 he was employed in Phillips Chemical Company's Cactus Ammonia Plant where he worked on design and maintenance of communications, electrical distribution and control systems. He transferred to Phillips Research and Development Department in 1954 and spent 18 months on development and application of gas analyzers. Since 1956 he has been chiefly concerned with development of capacitance type BS&W monitors along with control systems and other special instrumentation for LACT. He is a registered professional engineer in Oklahoma.

DATA READOUT PROGRAMER

Figure 5 shows the complete data readout system. The programer controls the readout sequence in step with the filling and dumping of the meter tank. When the transfer pump is running, the digital timer is energized, the monitor output is connected to the averager input and output pulses are accumulated on the BS&W counter. When the transfer pump stops, a one revolution master timer is energized in the programer to initiate the temperature and gravity readout cycle which must be completed before the tank is allowed to run to pipeline.

The master timer causes the averager input terminals to be switched from the monitor to the temperature transducer. One pulse is registered on the dump counter and the averager output is connected through a one minute gating switch to the temperature counter. On completion of this readout, the averager input terminals are switched from the temperature transducer to the gravity transducer and the averager output is connected through the gating timer to the gravity counter. On completion of this readout, the master timer releases measured oil to pipeline.

The gravity transducer and gravity counter are switched away from the averager so the monitor and BS&W counter can be switched in when the transfer pump restarts. This cycle is repeated for each fill and dump of the meter tank.

In a PD meter system, the BS&W monitor, capacitance cell and averager would be applied much the same as in the dump tank system. Gravity and temperature measurements would be made in the surge tank at the time the "normal-high" level was reached. The average "observed" gravity at the average "observed" temperature would be converted to gravity at 60° F when the run ticket is made. Because the fluid height is never static in the surge tank, the hydrometer type gravity transducer would be used.

This article is based on a paper presented at the 1959 Instrument Society of American Symposium, St. Louis, Mo. **—The End**

PART 1

Geologist's interpretation of drilling mud requirements

Electric logs and oil finding techniques will vary with different types of mud systems

By Dr. Hamilton M. Johnson, Geology Department
Tulane University, New Orleans

THE INCREASED COMPLEXITY of the drilling muds used to overcome the mechanical difficulties of drilling has presented new problems in formation evaluation. Very thorough studies, with case histories, have been published on these new muds in regard to their physical and chemical properties as related to a more efficient drilling operation, but very little has been done to assess the degree to which their use may interfere with geological evaluation of the formations.

As the depth of drilling has become greater, temperatures and pressures encountered have become higher and more complex mud types have become a necessary adjunct to drilling. This is not just a problem for the drilling engineer or the economist, but it is also a very serious problem for the geologist because almost each increase in operational efficiency of the drilling fluid in regard to drilling performance has correspondingly increased the difficulties of formation evaluation.

The most important tool used in formation evaluation today is the conventional electric log. It not only provides qualitative data concerning the lithologic sequence, but may often be used quantitatively in an estimate of the porosity and fluid content of the formations drilled. Since electrical logs are recorded with a down-hole system of electrodes surrounded by the drilling fluid, and since the results are greatly affected by the characteristics of the drilling fluid (including the filtrate from the drilling fluid and the mudcake formed by this filtering action), it is evident that a detailed knowledge of these factors is a necessity for accurate log interpretation.

The first muds used in rotary drilling were simple suspensions of surface clays in fresh water. A need to increase the density without unduly increasing the viscosity resulted in the use of iron-oxide additives and later in the more satisfactory use of barytes. With the recognition of a need for better suspending agents and a mud with good plastering qualities, the addition of bentonitic clays was begun. The use of sodium silicate to control heaving shales, oil base muds or inhibited muds to reduce hydration of shales, starch muds to lower fluid loss in muds with a salt water base, and of chemical thinners, followed in rapid succession. The advent of oil-emulsion muds brought on a need for emulsifiers and fluid loss control agents. The problem of lost circulation while drilling led to the use of plugging materials and recent developments of the oil base muds and invert-emulsion muds require still other additives.

As is obvious from this brief introduction to mud types, the field has become crowded with competitive products, designed to fulfill almost any need . . . from the drilling engineer's point of view. However, very little attention has been directed to the effect of these muds in hampering the geologist in his attempts at formation evaluation.

Mud Types. There are two distinct mud types: water-based muds, in which water (either fresh or saline) forms the continuous phase, and oil-base muds (including invert emulsion muds) in which oil forms the continuous phase.

The major types of drilling fluid in use today have been classified by Rogers[1] as:

- Fresh water muds (NaCl less than 1%, Ca less than 50 ppm)
  - A. Phosphate treated (pH to 8.5)
  - B. Caustic-Quebracho (pH 9.0 to 10.5)
  - C. Red mud (pH 11.5 to 13.0)
- Salt water muds
  - A. NaCl content from 1% to saturation
  - B. Saturated
- Calcium treated muds
  - A. Red lime muds

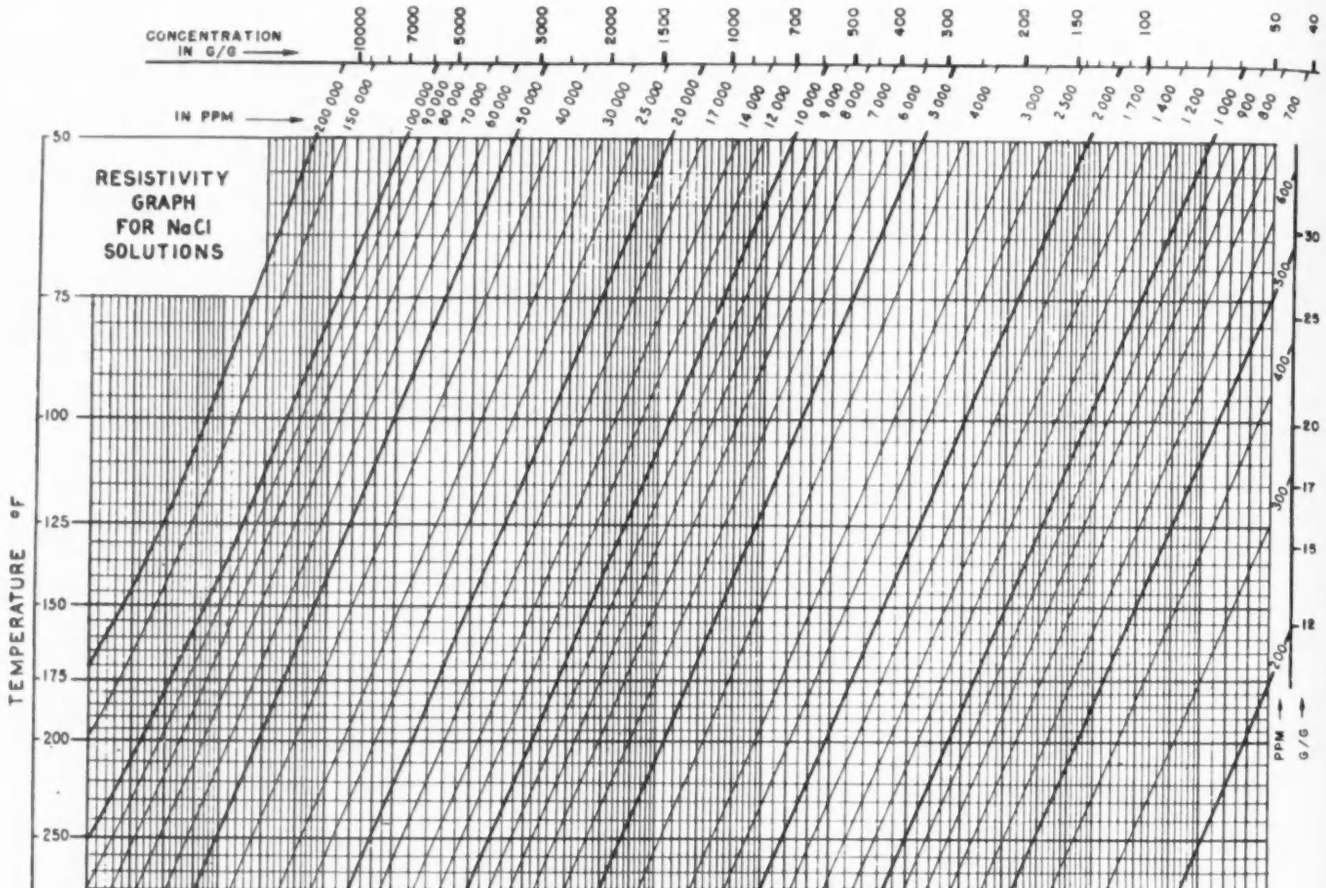


FIGURE 1—An increase in salinity will greatly decrease the resistivity. Each curve represents a separate salinity concentration.

B. Calcium chloride muds
C. Gypsum muds

- Oil-emulsion muds (with or without lime, starch, etc.)
- Oil-base or invert emulsion muds
- Sodium silicate muds

General Effects. Before beginning a detailed study of the individual mud types as classified above, a very generalized review of the entire field of logging requirements may be helpful. For example, it is necessary when recording the conventional log that the drilling fluid be sufficiently conductive electrically to provide a path for the electrical current to pass from the current electrode into the formation. However, while conductivity is required, the fluid must not be too conductive; excessive conductivity would only lead to short circuiting between the current and measuring electrodes, resulting in a greatly dampened, characterless, and misleading log. The salinity restrictions which place upper and lower limits upon the mud resistivity cannot be definitely assigned, for these depend upon the R_{mf}/R_w ratio. As a general rule, optimum results on the SP curve are obtained when the R_{mf}/R_w ratio is approximately five. (In Venezuela, the extremely saline formational waters of the Gulf Coast are absent and most formational waters range only from brackish to fresh. This means that the resistivity of the drilling mud must be much higher than in the Gulf Coast, if logs of equivalent quality are to be obtained A good rule-of-thumb for conventional electric logs in Venezuela would be that the best logs are obtained in muds having a resistivity in the two to five ohm-m range, at surface temperatures. Naturally, the salt water and sodium silicate muds will fall below the lower limit and the oil base muds beyond the upper limit.)

The various physical properties of the mud environment, such as hydrostatic pressure and temperature, and the chemical properties of the mud itself such as concentration and type of electrolyte and of added solids, all affect the resistivity but in greatly differing degrees. The most important are temperature, salinity, and pH. A summary might include:

Temperature: The resistivity decreases markedly with an increase in temperature as shown by the standard temperature vs resistivity curves of Figure 1.

Electrolyte: Increased salinity greatly decreases the resistivity, as illustrated in Figure 1, where a family of curves is plotted with a single curve representing each salinity concentration.

Increased pH decreases the resistivity, as shown in the extremely caustic mud of Figure 2. Excess sodium from the hydroxide lowers the mud resistivity just as much as would an equivalent amount of chloride.

Phosphates, soda ash, cement, anhydrite, lime and gypsum all tend to decrease the mud resistivity.

Solids: Organic compounds, if they are in a pure state, have little or no effect upon the resistivity of the mud. However, the starches may seriously reduce the S.P. effect (see Figure 3) and some of the organic compounds produce a filtrate which will fluoresce very similarly to crude oil.

Increasing the concentration of weighting additives increases the resistivity very slightly due to particle interference but this increase is negligible for all practical purposes.

An increase in cuttings in suspension, such as limestone chips and sand, may increase the resistivity slightly for the same reason but again, this increase is negligible.

Increase in concentration of the clay additives will decrease the resistivity slightly due to inherent soluble contaminating salts in these commercial clays. This decrease is comparable to the increase caused by weighting materials and the two usually nullify each other.

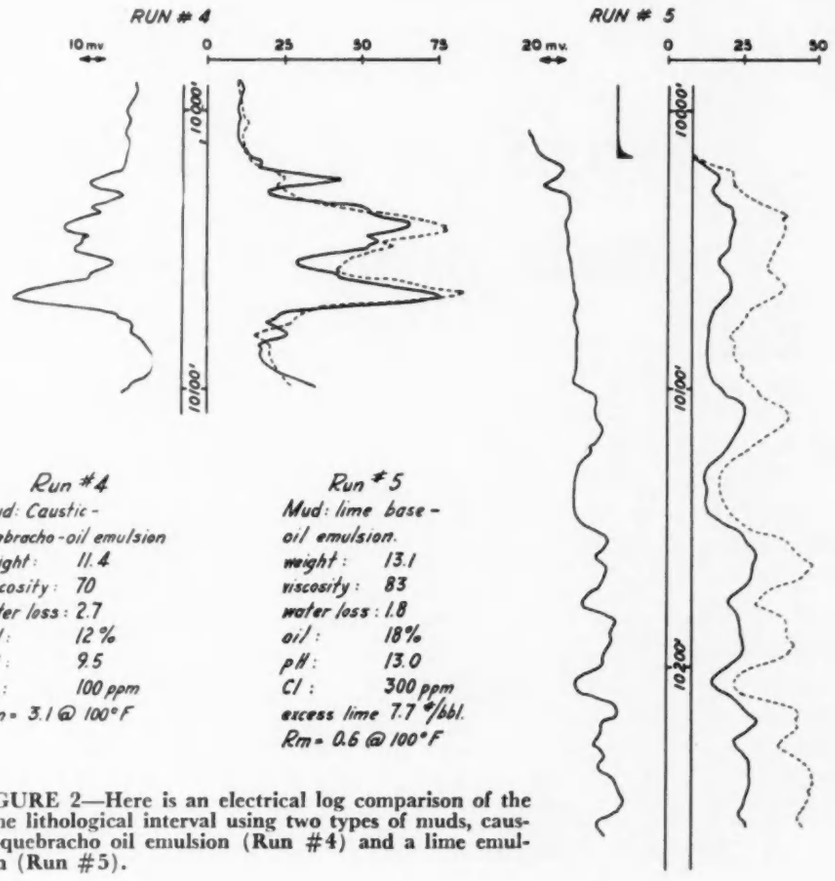


FIGURE 2—Here is an electrical log comparison of the same lithological interval using two types of muds, caustic-quebracho oil emulsion (Run #4) and a lime emulsion (Run #5).

Detailed Effects

1. Fresh-water muds (NaCl less than 1 percent, Ca less than 50 ppm) Fresh water mud is the basic type due to low cost and the ready availability of fresh water. All others are modifications used to overcome drilling conditions for which fresh waters are unsuited. These more complex muds are more expensive and more difficult to maintain.

A. Phosphate Treated (pH to 8.5) Phosphate muds are those in which one or more complex phosphates (metaphosphates, pyrophosphates, and polyphosphates) have been used as thinning agents. Usually some bentonite (for gel and wall plastering qualities) and some quebracho (to toughen the filter cake and lower water loss) are used. These phosphates are stable to only about 180° F., where they revert to orthophosphates and act as flocculants rather

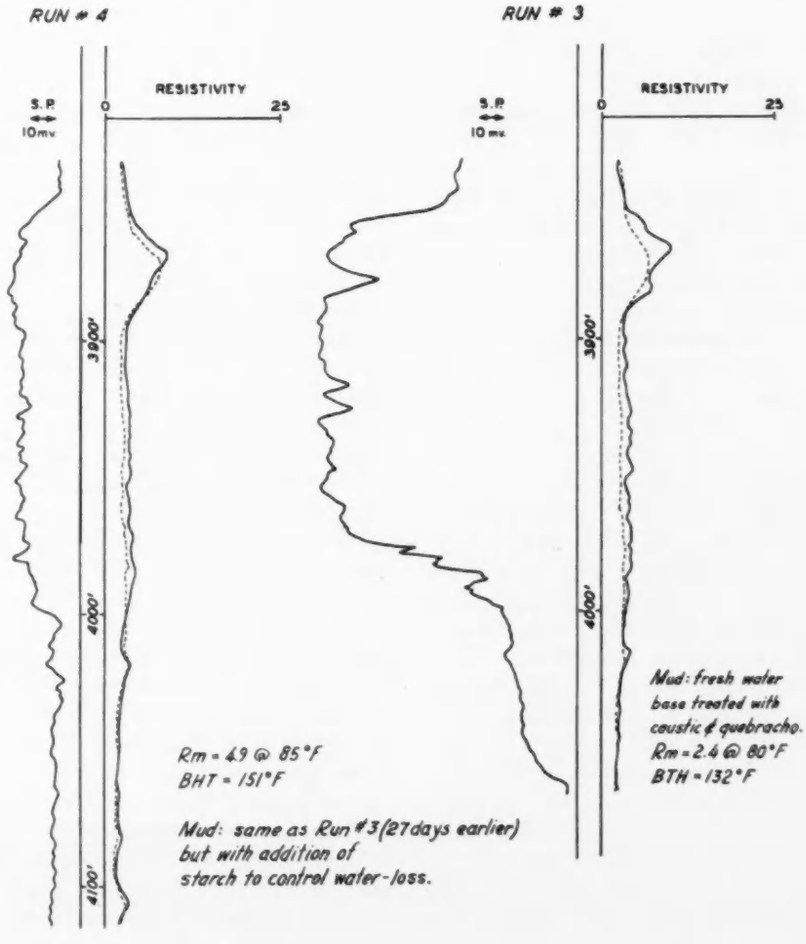


FIGURE 3—(right) The electrical log was changed through the addition of starch as a water loss controlling agent.

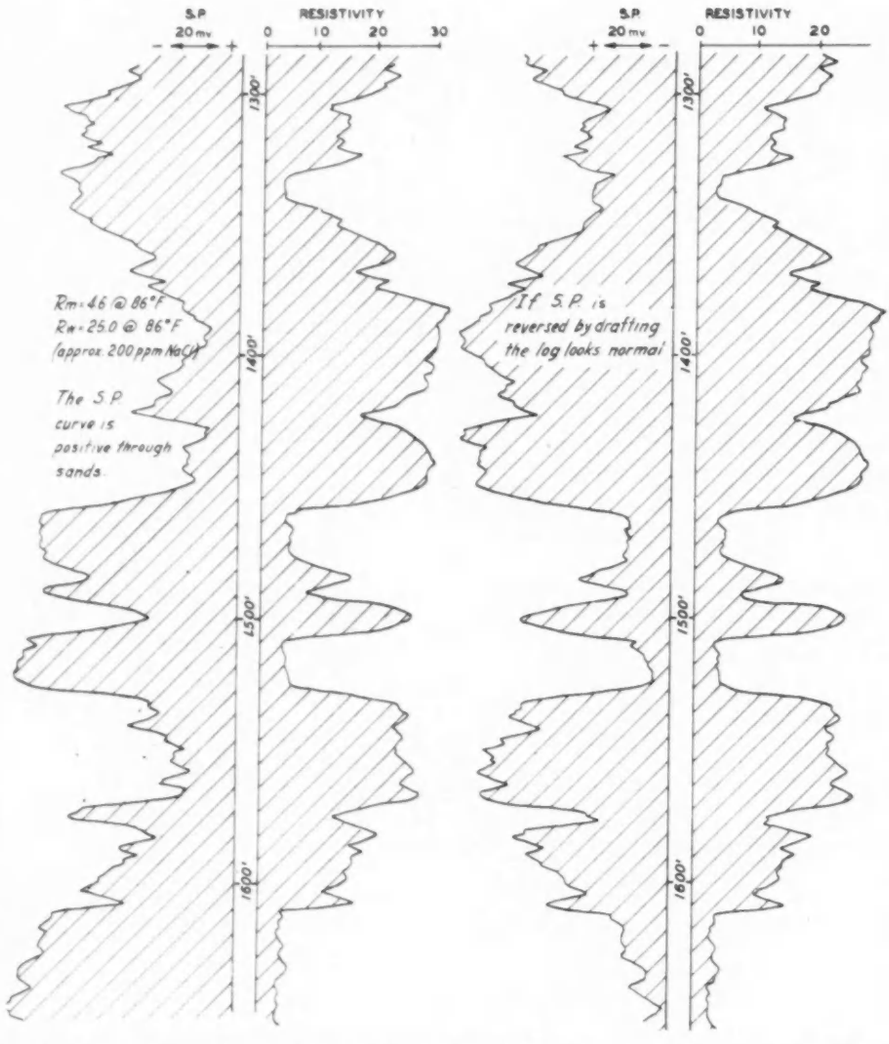


FIGURE 4—A positive SP curve will give entirely different picture over a negative approach.

than as dispersants; hence they cannot be used for very deep holes.

B. Caustic-Quebracho (pH 9.0 to 10.5) Caustic-quebracho muds are very similar to phosphate muds, but slightly more alkaline. Quebracho is used with caustic to maintain the desired viscosity. The pH of this mud is easily maintained, the chemicals are stable, and the treatment is effective at higher temperatures.

These two muds (phosphate-treated and caustic-quebracho) constitute the most commonly used muds, and entirely normal electric logs may be obtained in them. If optimum conditions prevail (i.e., R_{mf}/R_w about five and a very low water-loss), accurate interpretation can be made. All types of evaluation techniques are usable, including conventional electric logs, Micrologs, induction logs, analysis of sidewall cores, and mud (fluorescence) logging.

C. **Red mud** (pH 11.5) to 13.0. This is a caustic quebracho mud maintained at a higher pH by increasing the ratio of caustic to quebracho. The mud filtrate is pink to a deep red. The mud has low viscosity, low gel strength, low fluid-loss, and resists contamination. If starch is added for fluid loss control, the high pH will preserve the starch. (Starch, being an organic colloid, will ferment at pH less than 11.5). This mud is used primarily because of its resistance to contamination by anhydrite.

The high caustic content of this mud produces a low resistivity and the conventional electric log may not be effective. If the resistivity is too low, such logs as the Laterolog, Micro-Laterlog, and Gamma Ray should be used. The starch which is often used should be chemically inert but it has been noted that the S.P. curve is greatly damped; this may be due to reduction of the electrofiltration component by the reduced water loss. An example of this is shown in Figure 3.

2. Salt Water Muds Salt water muds are primarily adapted for use in areas where thick sections of salt or anhydrite will be encountered. If the salt water is from incidental contamination and the NaCl content can be kept at less than 1 percent, similar treatment as used for any fresh water mud may suffice. If the salt water concentration is greater than 1 percent, it may be necessary to use "salt water type" clays for building mud viscosity. The clays which expand in saline fluids consist of attapulgite, similar to Fuller's earth. The addition of pregelatinized starch may be necessary to control the fluid loss.

A salt water mud is a very low resistivity mud because the NaCl ions provide excellent conductive paths for the electrical current. The conductive paths thus provided distort the electrical field, so that it may no longer be assumed to be present in a homogeneous medium. Thus less current goes out into the formations and more passes directly from the current electrode to the measuring electrode up the borehole. This leads to apparently lower formational resistivities (a dampening of the curve). The S.P. anomalies are also flattened, as R_{mf} approaches the value of R_w. In fact, if R_{mf} is less than R_w, a positive anomaly of the S.P. curve will result. (See Figure 4).

Therefore, conventional electrical logs are unsatisfactory in a salt water mud. It is better to use a combination of Laterolog (for resistivity determination) MicroLaterolog (for porosity calculations), and Gamma Ray (for lithic determinations). The Gamma Ray is not affected by the borehole fluid and both of the other curves are measured by focusing instruments and reduce fluid effect to a minimum.

If the resistivity of the mud filtrate approximately equals the resistivity of the formational water ($R_{mf} = R_w$), the influence of the invaded zone is removed and a more exact determination of the true formational resistivity may be made. This is primarily of value only where it is extremely difficult to obtain quantitative values for R_t (in stratigraphic sequences where production is obtained from very thin stringers of high resistivity formations, such as limestones or very tight sandstones). Since the S.P. curve is useless with this mud, this is not often recommended.

TO BE CONTINUED

How to cross-check accuracy of velocity and seismic data

Instrumental and operational factors cause errors in velocity log and seismic data interpretation

By R. A. Broding, Vice President
Century Geophysical Corporation,
Tulsa

COMPARISON OF reference time shots with total log times taken from 25 unselected velocity log surveys run in wells in West Texas, New Mexico, Wyoming and Colorado indicates that 32 percent of the surveys tie to 1 percent or better and 84 percent tie to 3.5 percent or better, with a maximum error of 5 percent.

ERRORS IN VELOCITY LOGGING

Instrumental. The accuracy of any measurement is no better than the accuracy of the instrumentation used in making the measurement. Analysis of logging instrumentation errors indicates that the instrumental measuring accuracy is approximately plus or minus one percent. This includes all errors from time measurement to log recording. Thus, approximately half of surveys prove to be within the plus or minus one percent accuracy ascribed to logging instrumentation.

Operational. In considering errors that might be introduced in the physical operation of logging, consideration was first given to depth control. In general, accuracy is excellent; that is, better than 0.1 percent. The maximum error to be expected from normally straight holes would be approximately 0.4 percent (i.e. a drift of five degrees). Therefore, these errors are considered minor, relative to the instrumental accuracy of one percent.

Alignment of the sonde in the hole is important. Considering two-receiver systems only, any offset in the receivers will make the mud path to one receiver consistently greater than the other. In Figure 1, two conditions of present-type sondes are illustrated. These are assumed to be extreme conditions and are only illustrative of possible errors.

It is recommended that velocity logs be run coming *out* of the hole, rather than going into the hole. In the case of a semi-rigid sonde, the possible error resulting from a difference in the length of mud path is less than that for a flexible insulator type. This reasoning is based on the possibility of misalignment of the sonde. The semi-rigid sonde has an advantage in that the over-all length of the sonde limits the misalignment in a given bore hole, while the flexible insulator type is limited primarily by the wall of the hole.

For example, a 4-inch offset between the top and bottom of a sonde

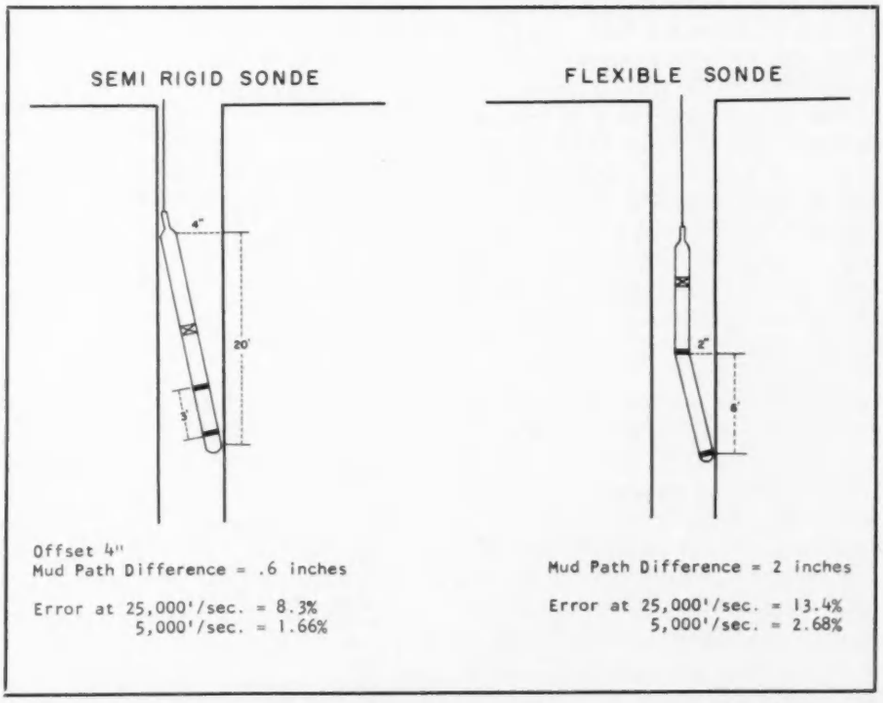


FIGURE 1—Possible error is considerably less in the case of a semi-rigid velocity logging sonde (left) than that of the flexible insulator type. Semi-rigid sonde is advantageous in that its over-all length limits misalignment in a given bore hole, while the flexible type is limited mainly by the wall of the hole. Since the misalignment error can be significant, logs run coming out of hole are preferred to those run going into hole.

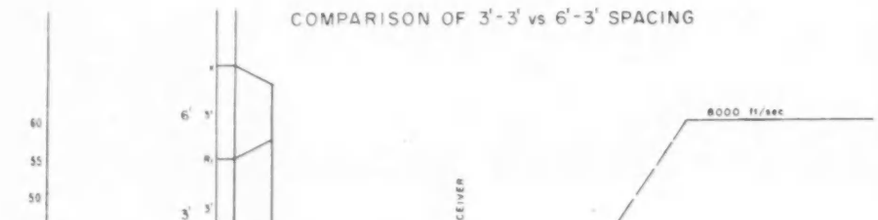


FIGURE 2—Spacing between transmitter and first receiver is very important to accuracy of velocity log surveys where the hole is caved, of large diameter, or where highly altered shales are present. The (sometimes) significant errors (20 percent or more) can be detected by using two logs of different spacing or spans, since the logs will not duplicate in zones of error.

20 feet long could give an error of approximately 8.3 percent in 5,000-feet-per-second rock for a 3-foot span. It appears logical that a flexible type sonde could have a greater offset since there is little restoring force to keep the receivers in alignment. For a 2-inch offset, an error of 13.4 percent can be obtained at 25,000 feet per second and 2.18 percent at 5,000 feet per second, using a 6-foot span. This effect can be severe, hence logs run coming *out* of the hole are preferred.

The effects of caves on a two-receiver log are strong. However, the effect is fortunately opposite as each pair of receivers pass the top and bottom of a cave. Hence, integrated time from the log is self-compensating and errors are small, except where the cave is sufficiently great to exceed the minimum acoustic hole diameter.

The importance of the spacing between the transmitter and first receiver has been brought out by Kokesh and Blizard[1] and Hicks.[2] This error can be great (i.e. 20 percent or more) and is one of the important potential sources of error in present techniques. For example, in 6,000-feet-per-second rock, using a 3-foot transmitter-to-first receiver separation, caves in excess of 5 inches from the edge of the sonde are potential sources of error (Figure 2).

In general, this is not bothersome until one logs in a large diameter bore hole, one that is highly caved and in a low-velocity formation, or one containing highly altered shale. Unfortunately, there is no means of determining if this error is present from a single curve. It can be detected by using two logs of different spacing or spans, as the logs will not duplicate in zones of error. Hence, it is recommended that in areas of damaged shales a spacing of 6 feet or more from the transmitter to the first receiver be used and, preferably, a combination of spacings or spans be used to isolate problem areas.

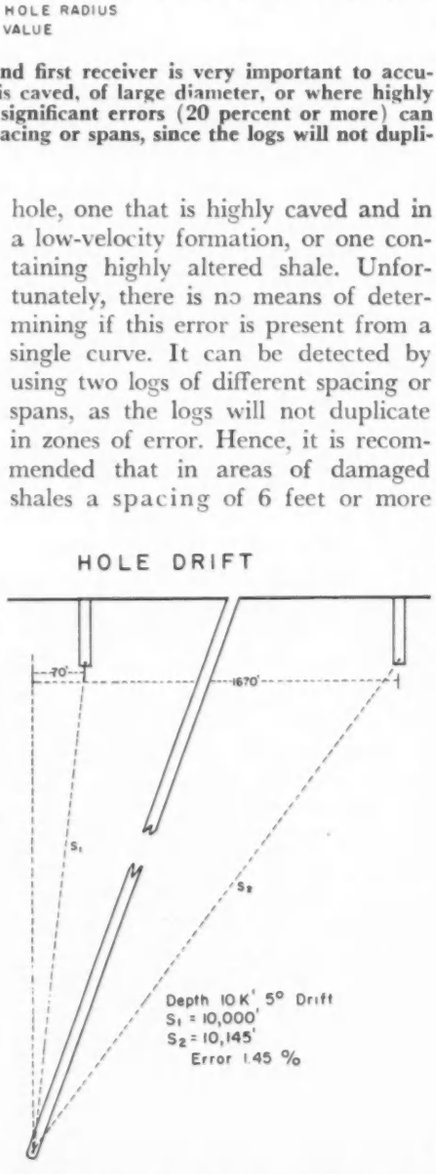


FIGURE 3—Typical seismic survey arrangement, indicating maximum error of seismic velocity measurement owing to five-degree hole drift. Horizontal scale is exaggerated.

The span selected between receivers is not critical, as with proper design instrumental timing accuracies are in excess of other errors. The choice is one of desired detail in the log. A 3-foot span is a good compromise in detail or required bed resolution.

Formation damage. Errors introduced by damage to the formation surrounding the bore hole from drilling are not easily detected unless a two-span or two-spacing log is obtained.

Errors resulting from displacement of fluid (i.e., change in fluid salinity in the invaded zone) also are possible; however, the magnitude of such errors is small, i.e., less than 1 percent. This value was arrived at from data of Wyllie.[3]

Consideration has been given to effect of temperature, since the temperature gradient surrounding a new well is quite different from the earth's normal gradient. For temperature differences in the order of 50° F, the error may approach 1 percent. This figure was arrived at from Wyllie, assuming a constant salinity.[3] Therefore, it is significant; but fortunately the error is self-compensating as the bottom of the hole is below, and the top is above, the normal rock temperature.

The effects of pressure were estimated and are considered to be negligible, as most wells work on a pressure differential between the formation and the bore hole hydrostatic pressure of less than 5 percent. This would result in errors of less than 1 percent. This value was derived from Hicks.[4] Further, a good portion of the pressure differential is across the mud cake, hence pressure effects on the formation rock can be neglected.

From this it is reasoned that the most important potential sources of error are in the sonde position in the hole and the acoustic hole diameter for a given transmitter-to-first receiver spacing. Both can be minimized by using proper equipment and techniques.

SEISMIC REFERENCE SHOTS

Instrumental errors. The instrumental timing errors and ability to pick first breaks is typical of any seismic operation. The pick of a good

break should be to 1 millisecond. Therefore, timing errors obtained from good data are better than 1 percent and often better than 0.1 percent.

Operational errors. Physical errors, such as hole drift, indicate errors of 1.45 percent or less since the maximum drift one needs to expect is five degrees. A typical survey arrangement is shown in Figure 3.

It is possible for the ray paths of tie shots to traverse different sections as a result of dip, faults, differential ray paths or near-surface velocity variations. Figure 4 illustrates the dip problem, Figure 5 the fault problem and Figure 6 the weathering problem. By shooting into a given reference level from more than one side, errors resulting from these effects can be detected by the lack of time tying. Therefore, it is always recommended that at least two sides be shot into each check level. If up-hole surveys are run on both sides, appropriate corrections can be made for weathering errors.

The possibility of precursories from cable breaks or casing breaks is always present. Proper field techniques (i.e. spacing of shot point from well and use of a pressure phone) usually limit such effects. Through use of multilevel recording of the well seismometer signal, the character of the break also can be studied to evaluate any suspected precursory.

Formation damage. Errors can be obtained by formation damage around the shot point or shot hole fatigue. By using control from a lag phone, fatigue can be detected and corrected.

Summary. Reference shot times can be relied upon if the time ties from two or more sides check and the quality of breaks is good. Any errors in a seismic reference point can be qualified from the seismogram. If good data are acquired, better than 1 percent accuracy should be obtained. For this reason the reference time is considered the "true time."

Integration of the sonic signal as the log is being run is inherently as accurate as the prime data, or within 1 percent. Unfortunately, the need for time correcting integrations of the raw data from the seismic tie shots involves re-integration by tracing methods in present procedures. These re-integrations are considered to have an accuracy of plus or minus 1 percent. Therefore, the final integrated log cannot be considered better than plus or minus 2 percent, allowing a 1 percent error for log tracing integration means. Time integrations corrected by tie shots can be relied upon to the accuracy of the tie shot (i.e. plus or minus 1 millisecond).

If differences in log data are found to be in excess of 2 percent, the log data is considered to be in error. Intelligent appraisal of the log data, with the reference check shots, will generally point to possible sources of error. Such studies, combined with statistics on errors obtained from numerous surveys, are the best guide to improvement in this procedure.

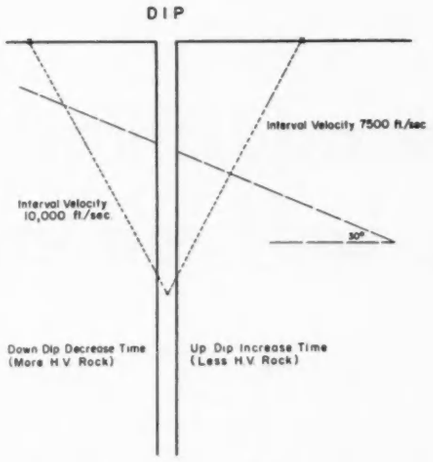

DIP
Interval Velocity 7500 ft./sec
Interval Velocity 10,000 ft./sec
30°
Down Dip Decrease Time (More H.V. Rock)
Up Dip Increase Time (Less H.V. Rock)

FIGURE 4—Steep dips, in this case 30 degrees, can be a source of error in seismic velocity surveys. In this example, a high-velocity formation is encountered at shallower depth updip (left), decreasing the time interval surveyed as compared with energy received from farther downdip.

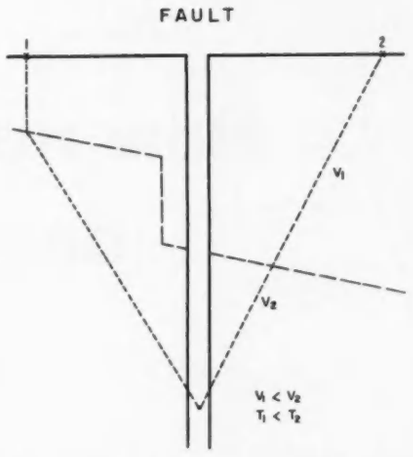


FIGURE 5—Similar to the dip problem illustrated by Figure 4, a high-velocity formation is encountered higher (left) owing to the position of the fault plane, resulting in a possible velocity mis-tie.

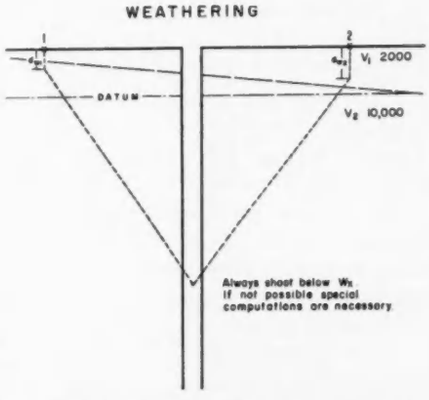


FIGURE 6—Weathered zones pose problems in seismic velocity surveys. The weathered zone may be inclined or otherwise not parallel to the surface. It is important to know whether shots are made in, or below the weathered mantle.

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[3] M. R. J. Wyllie, A. R. Gregory and L. W. Gardner, "Elastic Wave Velocities in Heterogeneous and Porous Media", *Geophysics*, Vol. 21, No. 1, January 1956 (Figure 3).

[4] W. G. Hicks and J. E. Berry, "Application of Continuous Fluid Saturation of Rocks from Velocity Logs," *Geophysics*, Vol. 21, No. 3, 1956 (Figure 2).

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About the Author

R. A. Broding received his B.S. degree in electrical engineering from the University of Minnesota in 1939.

After serving in the geophysical department of Magnolia Petroleum Company as an electrical engineer, he worked from 1942 to 1943 on magnetic firing devices as a member of the Naval Ordnance Laboratory. From 1943 to 1953 he continued work for Magnolia on various seismic and electrical prospecting methods. Broding organized and directed a research group that developed magnetic and acoustic well logging instrumentation, including the continuous velocity log. Since 1953 he has been technical vice president of Century Geophysical Corp.

PART 1

How new additives improve deep well cementing

They . . . 1. Control setting time 2. Lower the water loss 3. Widen the density range

By J. O. Woodson, Engineer
Phillips Petroleum Company, Midland, Texas
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DURING 1958 Phillips Petroleum Company completed drilling operations on three deep wells in Pecos County, Texas. All three wells were drilled below 19,000 feet. Two of the wells surpassed the depth record as it existed at the beginning of 1958. When drilling operations were completed and production tests begun on the three wells, a cumulative total of 67,760 feet of hole had been drilled, and 14 separate strings of casing, totaling 136,790 feet feet had been set and cemented. This accomplishment required the complete cooperation of Phillips Petroleum Company personnel with the many companies engaged to perform the various operations necessary to drill and complete these wells. This report of the various cementing operations is typical of the engineering, planning, and cooperation between operator and service company that went into each phase of the drilling operations.

Development of the materials and equipment which made possible the successful cementing of these wells was begun several years ago. Consequently, materials and techniques used were not experimental in any respect. This does not mean, however, that each individual job was not carefully engineered with respect to both materials and equipment. The exact cement blends and cementing equipment to be used on each cement job was selected only after careful planning and study. The engineering that goes into the cementing of a well is just as important as the engineering performed during any other phase of the drilling or completion operation.

Materials. Although this article is primarily concerned with the cement jobs performed on three particular wells, some of the general developments in the field of cement technology, as they pertain to oil-well cementing, should be discussed.

The materials used in cementing operations can be divided into general classes, depending upon the function of the material. Basically, the primary material is cement. Portland cement is the oldest and has been the most widely used type of cement. Although one might assume that a material which has been used as long as portland cement could be altered very little in its properties, this is far from true. At the time when wells were no deeper than 5,000 or 6,000 feet, common portland or construction cement could be used for all cementing operations on these wells. As wells were drilled deeper with accompanying increases in down-hole temperatures and pressures, it soon became apparent that common portland cement could not meet all the needs of the petroleum industry. A cementing service company developed and patented the first retarded set cement which could be pumped to greater depths than the construction cements. As the industry grew more specialized, cements such as the sulfate resistant types were developed. The many types of portland cement developed led to an API system for classification and the development of API specifications for these cements. This system now provides for seven classes in regular and sulfate resistant types.

There is a narrow density range to which neat cements should be slurried. For most neat cements, this density range is in the order of 1.5 ppg with

TABLE 1—A comparison of properties of slow-set cement blended with silica flour to barite cement and neat slurries

CMHE C Percent	Silica Flour Percent	Barite Percent	Density Lb./Gal.	Water Loss	API SCHEDULE 10 & 10S	
					Thickening Time	24 Hour Compressive Strength
2.0	22.5	....	14.5	2.5	4:45	4850
2.0	22.5	....	15.0	2.5	4:29	6640
2.0	22.5	....	15.5	1.8	3:02	5450
2.0	22.5	....	16.0	1.2	No Run	6150
1.5	....	63.9	16.0	....	3:17	840
1.7	....	63.9	16.0	....	4:00 Plus	775
2.0	....	63.9	16.0	....	No Run	690
2.0	....	42.6	14.9	....	2:35	....
	....	....	16.0	....	Less Than 1:00	2140
1	....	....	16.0	....	2:08	....
2.0	....	....	16.0	....	....	2675
2.0	....	....	15.0	....	3:02	....

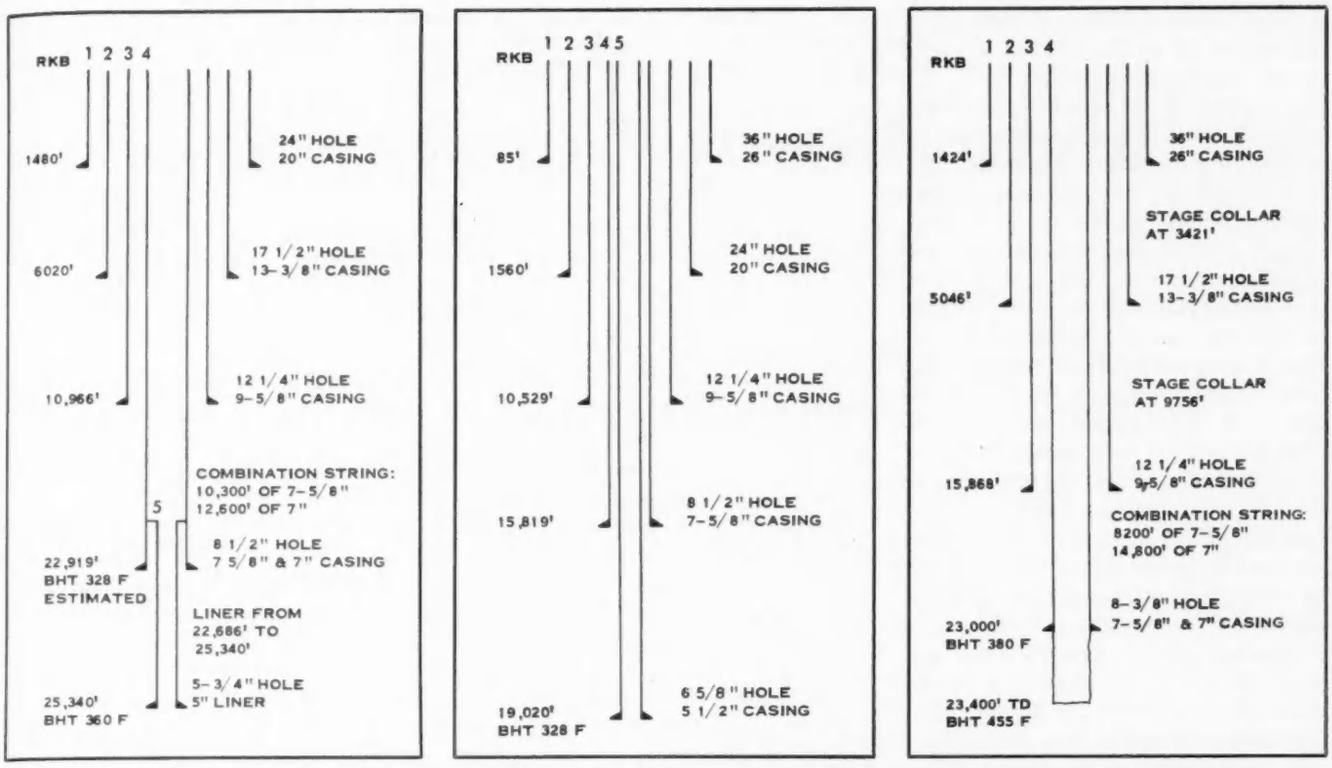

FIGURE 1—Casing strings and primary cementing data for the three deep tests drilled by Phillips Petroleum Co. in Pecos Co., Texas.

CEMENT AND DISPLACEMENT

University EE 1

1. A total of 2000 sacks of regular cement with 4 percent bentonite plus 200 sacks of regular cement. Displacement 528 barrels.
2. A total of 1,685 sacks of regular cement with 40 percent diatomaceous earth and 4 percent calcium chloride at 10.9 pounds for gallon plus 200 sacks of regular cement at 15.5 ppg. Displacement 906 barrels.
3. A total of 950 sacks of regular cement with 40 percent diatomaceous earth at 10.8 ppg plus 300 sacks of slow set cement at 16 ppg. This slurry was displaced through perforation at 10,888-90 feet. Displacement 625 barrels.
4. A total of 1,147 sacks of slow set cement with 40 percent diatomaceous earth and 1.5 percent CMHEC at a slurry weight of 10.8 ppg plus 100 sacks of slow set cement with 1.5 percent CMHEC at 15.8 ppg. Displacement 951 barrels
5. A total of 136 sacks of slow set cement with 20 percent diatomaceous earth and 3 percent CMHEC at 12.3 ppg. Displacement of 205 barrels.

Harral A-1

1. A total of 400 sacks of regular cement with 1 percent calcium chloride.
2. A total of 2,000 sacks of regular cement. Displacement 557 barrels.
3. A total of 1,500 sacks of regular cement with 60 percent diatomaceous earth at 10.5 ppg plus 300 sacks of slow set cement at 15.8 ppg. Displacement 780 barrels.
4. A total of 1,219 sacks of slow set cement with 60 pounds of barite added per sack and 0.5 percent CMHEC at 17.5 ppg. Displacement 726 barrels.
5. A total of 400 sacks of slow set cement with 10 percent diatomaceous earth and 1 percent CMHEC at 13.6 ppg. Displacement 427 barrels.

Montgomery A-1

1. A total of 1,662 sacks of regular cement with 4 percent bentonite at 14 ppg plus 300 sacks of regular cement at 16 ppg. Displacement 508 barrels.
2. Top stage: A total of 1,109 sacks of regular cement with 40 percent diatomaceous earth and 4 percent calcium chloride at 10.8 ppg plus 100 sacks of regular cement at 15.4 ppg. Displacement 520 barrels.
   Bottom stage: A total of 302 sacks of regular cement with 40 percent diatomaceous earth and 4 percent calcium chloride at 10.8 ppg plus 400 sacks of regular cement at 15.4 ppg. Displacement 768 barrels.
3. Top stage: A total of 1,050 sacks of regular cement with 40 percent diatomaceous earth at 10.8 ppg plus 300 sacks of slow set cement. Displacement 754 barrels.
   Bottom stage: A total of 1,700 sacks of regular cement and 40 percent diatomaceous earth and 0.75 percent CMHEC at 10.8 ppg plus 364 sacks of slow set cement. Displacement 1,226 barrels.
4. A total of 1,099 sacks of slow set cement with 16 percent diatomaceous earth and 2.5 percent CMHEC at 12.7 ppg plus 150 sacks of slow set cement with 0.5 percent CMHEC at 16.3 ppg. Displacement 898 barrels.

---

a minimum density of 15.4 ppg for API Class A cements and approximately 16.0 ppg for API Class E cements. The proper density range might vary with different brands of cement but will be determined in each case by the water-cement ratio that must be used to provide a pumpable slurry, yet one that will not result in separation of free water upon setting. When a cement is mixed heavier than the recommended density, its thickening time may be materially reduced or the slurry may be too thick to be pumped. On the other hand, when a cement is mixed lighter than the recommended minimum density, separation of the solid particles from the slurry may occur to the extent that free water pockets will exist within the cement column. The amount of

mixing water required will depend to a great extent on the fineness of grind of the cement used.

Inasmuch as it usually is desirable to mix a cement to a density equal to or only slightly greater than the mud density used to drill the well, it becomes obvious that density control of cement slurries over wide ranges is a desirable property. Materials used for density control can be divided into two classes: weighting materials and light-weight materials. A common material used to increase cement-slurry density is drilling-mud barite. Other materials such as iron arsenate, galena, ottawa sand and, most recently, ilmenite ore have been used for this purpose. Ilmenite ore allows the formulation of heavier cements without the viscosity problems associated with barite.

Because cement slurries are relatively high on the mud-density scale, more effort has gone into finding suitable materials which can be used to reduce the density of these slurries. One of the first light-weight materials to be added to cements was bentonite. This material is still widely used. Bentonite allows more water to be added to the cement without causing separation of the solid particles. The next material to attract a great deal of attention was expanded perlite. This material is normally used with bentonite cement slurries. The addition of the bentonite in the perlite cement blend reduces the flotation of the perlite particles and results in a more uniform slurry. The additional water required for both the perlite and bentonite results in a lighter-weight slurry. As expanded perlite breaks down under pressure allowing fluid to saturate the interior of the particle, the slurry weight of cement containing this material increases as it is pumped downhole. For this reason, slurry weights on the surface must be carefully controlled to assure the proper weight and viscosity in the well under pressure.

The next development in light-weight slurries was the addition of pozzolanic materials to cement. This resulted in a cementing material having the advantage of density control in the range of 13.5 to 15.5 ppg without the susceptibility to deterioration by corrosive waters experienced with bentonite cements. Other properties such as better perforating characteristics and less expansion on setting were achieved.

TABLE 2—These blends were used in the squeeze and plug back operations in the University EE-1 and the Montgomery A-1 wells

WELL DEPTH	CMHEC Percent	SiO_2 Percent	Density Lb./Gal.	Slurry Vis.
20,000-TD	2.0	22.5	14.5	Very Low
18,000-20,000	1.5	22.5	14.8	Very low
17,000-18,000	1.0	0	15.8	High
16,000-17,000	.7	0	16.0	Mod. high
15,000-16,000	.5	0	16.3	Sl. high
10,000-15,000	.3	0	16.5	Sl. high
	Sodium Silicate	**CMHEC**		
Surface—10,000	.3	.5	16.0	

The most recent development in density control is the use of diatomaceous earth. This material is an additive containing very little aluminum. It permits a tremendous amount of water to be added to the cement slurry without separation of the solid particles. This material was used for density control in cementing the three deep wells to be discussed in this paper.

The slow-set cements available from the cement industry cannot be expected to meet all of the conditions encountered in oil-well cementing. However, they are excellent starting materials for many modifications. These modifications normally include retardation and water-loss control, as well as density control. A number of materials have been used as cement retarders. One of the first of these was common sugar. Although an excellent retarder, this material had many disadvantages. Other retarders used with varying degrees of success have included oxidized cellulose, sodium tannate, dextrin, pyrogallic acid, and calcium lignosulfonate. The most recent development in the field of retarders is the tongue twister, carboxymethyl hydroxyethyl cellulose (CMHEC). Like many other retarders, this material incorporates other desirable properties along with retardation. Most retarders are also dispersants. On the other hand, CMHEC helps suspend the cement particles, and thus is a very good material to use with weighted cements.

This material also imparts effective low-water-loss characteristics to cement slurries. Many retarders reverse their action and become accelerators at high concentrations. As CMHEC does not have this characteristic, it could be used to successfully retard cements for the extremely deep wells drilled in Pecos County. This material has been used for cement retardation in other deep, high-temperature wells such as the Richardson & Bass-Mecom-Freeport-Humble-LL&E-State 2414, Well 1-L in South Louisiana and Shell Oil Company's Rumberger 5 well near Elk City, Okla.

Oil-well cements must be retarded under deep-well conditions because increased temperatures and pressure reduce the thickening time or pumpability of the slurry. In addition, high temperatures and extreme pressures have other effects upon cement slurries placed and set under these conditions. Members of the Mid-Continent District Study Committee on Cementing Practices and Testing of Oil-Well Cements made studies, both collectively and individually, of the effects of high temperatures and pressures on the strengths of hardened oil-well cement slurries.

These studies show that cements attain lower early strengths when cured above a certain maximum temperature, or that they lose strength with time at temperatures above this critical temperature. Any cement cured above this critical temperature reaches a maximum strength and then begins to lose strength with time. The point at which this maximum strength is reached depends upon the curing temperature.

It also was found that an increase in the pressure at which the cement is cured decreased the amount of strength retrogression and increases the temperature at which this retrogression begins. The amount of aluminum present in the cement mixture has an effect on this strength retrogression. The retrogression is lessened and begins at a higher temperature with small tricalcium aluminate content. It has been found that the addition of moderate amounts of silicon dioxide to the cement mix will reduce or eliminate this strength retrogression. Again, the aluminum content of the admix should be small to obtain the maximum benefit. Two important

Continued on Page 145

How to correct and interpret gravity data

Geophysicists should analyze gravity anomalies through geological, geophysical reasoning; diagnostic evaluation by geologists is needed

By Raoul Vajk

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Standard Oil Company (New Jersey)
New York City

THE AIM of gravity exploration is to determine the variations of the earth's gravity field at the surface of the earth and to draw geological conclusions from the observed variations of the gravity. As the variations of gravity are due only *in part* to geological causes, the effects of factors other than geological must be eliminated from the gravity data before the variations of the gravity are translated into geological terms. Thus, certain corrections must be applied to the observed gravity data.

The most important corrections of gravity data in exploration are latitude correction, elevation correction (free-air and Bouguer) and, to some extent, terrain and regional corrections. Geologists may find some isostatic anomaly maps useful in regional geological studies. Other less significant corrections are mentioned to illustrate the complexity of gravity anomalies. The importance of the individual corrections may vary according to the purpose of the gravity investigation and according to the type of area surveyed.

1. Normal gravity and latitude correction. The acceleration due to gravity at the surface of a homogeneous earth model is a function of latitude only. A formula expressing the gravity value on the surface of such an ideal earth has been computed using a great number of gravity measurements at various latitudes. This ideal earth is called *reference ellipsoid,* and the theoretical gravity value at a point on the surface of the reference ellipsoid is called NORMAL GRAVITY.

The normal gravity for any latitude on the earth's surface is given by the 1930 International Formula: $g\varphi = 978.049\ (1 + 0.0052884 \sin^2\varphi - 0.0000059 \sin^2 2\varphi)$ cm/sec^2 where φ is the latitude (north or south). Deducting the normal gravity from the observed gravity value, we find the *gravity anomaly* at the point of the earth's surface where the observation was made.

In a practical survey, we measure relative gravity, that is, the differences between the gravity at an arbitrarily chosen base station and the gravity at the various field stations in the area under investigation. These differences include: (1) THE VARIATIONS OF THE GRAVITY ANOMALY between the base station and the various field stations, and (2) THE VARIATIONS OF THE NORMAL GRAVITY between the base station and the field station.

We are interested only in the variations of the gravity anomaly as only these furnish information about the subsurface geology. Hence, we have to eliminate variations of normal gravity. The variation of normal gravity is, of course, the difference between normal gravity at the field station and normal gravity at the base station. This difference is called LATITUDE CORRECTION. Latitude correction eliminates gravity changes caused by the oblate shape of the earth and effects of changes of centrifugal force in the north-south direction.

2. Elevation corrections. Because of topographic features, gravity observations are made at varying altitudes. Variations in the altitude of gravity measurements result in variations of gravity not attributable to geological reasons. To eliminate "nongeological" gravity variations, all gravity data must be reduced to a common level, usually sea level. In the following discussion, elevation or altitude means absolute elevation, i.e., elevation above sea level.

Free-air correction. Measuring gravity at the top of a building and at ground floor, we find that the gravity force at the top is less than at the ground because the top of the building is farther away from the center of the earth (here we may disregard the gravity effect of the building). Gravity decreases by 0.3086 milligal for each meter of elevation above the surface of the earth if there is nothing but air between the earth's surface and the point where gravity is measured. The correction applied purely for this variation of gravity is called *free-air correction.* This correction is sometimes called, especially in European geodetic literature, "Faye" correction. This correction does not consider the gravity effect of the rocks forming the topography, but only the increased distance from the center of the earth.

Bouguer correction. A French geodesist, Bouguer was the first to consider the gravity effect of the rocks forming topography and gave a formula for eliminating it from anomalies observed. In his computation he considered an infinite horizontal plate of rocks. The "thickness" of the rock plate is the elevation of the gravity station. If the density of the rocks forming the hill is 2.4, then about 1

milligal must be subtracted from the observed gravity values for each 10 meters of elevation.

Terrain correction. Bouguer used an approximation when he derived his formula. He considered a plateau extending infinitely in the horizontal direction instead of the finite (conical, ridge-like, or irregularly shaped) hill. If the topography is rugged and abrupt elevation differences occur in the vicinity of the gravity station, then another correction called terrain correction is needed.

For COMPUTING THE TERRAIN CORRECTION, detailed maps with accurate elevation contour lines are needed, or the vicinity of the gravity station must be surveyed for elevation variations. From these elevation data the terrain correction is computed with the aid of any of the various formulas or graticules available in the literature. The terrain correction is applied to augment the Bouguer correction.

Gravity values corrected for latitude, elevation (free-air correction and Bouguer correction), and for the irregularities of the topography (terrain correction) are called Bouguer anomalies, and the map showing these anomalies is the Bouguer gravity map, or simply *Bouguer map*. If only latitude and free-air corrections are applied to the gravity values, the map showing these gravity anomalies is called a *"free-air anomaly map."* Free-air anomalies are used in isostasy studies. Free-air and Bouguer corrections together are usually called ELEVATION CORRECTION, since both are functions of the elevation of the gravity station above sea level.

The Bouguer correction and terrain correction together may be called TOPOGRAPHICAL CORRECTION since both are determined by the topography of the area (and of course by the density of the rocks forming the topography).

3. Regional correction. The Bouguer gravity map often shows a strong gravity effect due to some dominant, deep-seated geological feature which veils or considerably alters gravity anomalies due to geologic structures of possible economic interest. Such dominant, widely extended and gradually changing gravity effects are called REGIONAL GRAVITY. The regional gravity effects should be eliminated from the Bouguer gravity anomalies in order to obtain a clearer, undisturbed picture of the gravity anomalies of the subsurface geological structures of practical importance.

No other field in gravity interpretation—with the possible exception of isostasy problems—has caused so much controversy as the correction of gravity anomalies for a regional effect. The basic reason for all these controversies is that determination of true regional effect is impossible. The problem boils down to determining the components of a sum, when we do not know how many numbers were added.

Failure to recognize this basic limitation led to development of various methods for arriving at a regional effect in an area. These methods are still used mainly because they can be applied mechanically by nontechnical help and because they furnish quick results. They may be divided into three groups: first, arithmetical, various "grid" methods; second, graphical, smoothing the isogams or the gravity curves; and third, mathematical, using elaborate mathematical methods, usually from the field of theoretical statistics, or analytical geometry of space. All of these methods have their fallacies. The author prefers a fourth method, i.e., to ANALYZE THE GRAVITY ANOMALIES AND BREAK THEM UP INTO COMPONENTS, CONSIDERING GEOLOGICAL AND GEOPHYSICAL PRINCIPLES. This method is also arbitrary, but at least it is based on geological and geophysical reasoning rather than on purely mathematical considerations.

Subtracting the regional gravity effect (determined by one of the methods listed above) from the Bouguer anomalies is called "regional correction." The resulting anomaly is the *residual anomaly*. RESIDUAL ANOMALIES ARE ASSUMED TO BE GRAVITY ANOMALIES DUE TO INDIVIDUAL GEOLOGICAL STRUCTURES.

Bouguer and residual gravity maps represent a coded message about subsurface geological conditions, and the task of geophysicists and geologists is to break this code.

4. Isostatic correction. The earth's crust consists mainly of granitic and basaltic (gabbroic) rocks while the subcrust (or mantle) is composed of ultrabasic rocks. The density of the crust is less than the density of the subcrust. Generally, a density of 2.67 is assumed for the crust and 3.27 for the subcrust. The crust is 30-40 kilometers thick at the continents and about 5 kilometers thick beneath the ocean.

According to Airy's theory of isostasy, the subcrust is latent-plastic, i.e., it slowly yields to pressure. Continents partially sink into the dense subcrust and float as icebergs in water. Under high mountains the relatively light crust sinks deep into the subcrust, thus forming "roots." The buoyancy of these "roots" holds up the mass of the mountains. If isostatic equilibrium exists, the buoyancy of the "root" is equal to the weight of the mountain-mass above sea level. If the "root" is buoyant enough the area tends to rise; if buoyancy is insufficient, the area tends to sink.

From a topographic map, using an average density of 2.67, the weight of the mountains above sea level is computed, and then using a density difference 0.6 (between the densities of the crust and the subcrust) the volume of the mountain "root," which would carry the weight of the mountains by its buoyancy, is computed. Then the gravity effect caused by this "root" is computed. This gravity effect is called the "correction for compensation." Applying free-air, Bouguer, terrain, and compensation corrections (and some other minor corrections) to the observed gravity we find the ISOSTATIC ANOMALIES.

If the isostatic anomaly is negative, then the topographic feature is "overcompensated" by the "root"; if the isostatic anomaly is positive, "undercompensation" is present. In the first case, the area tends to rise, and in the second case, to sink. These conclusions are valid, of course, only if the assumptions used in the theory of isostasy are correct. The most limiting factor in isostatic correction is the assumption of constant density of the crust. Large sedimentary basins filled with light sediments contain rocks with an average density considerably lower than the value of 2.67 used commonly in isostatic computation. The adjustments for such lower densities are called geological corrections.

ISOSTATIC ANOMALY MAPS SHOULD INDICATE THE BASIC HYPOTHESES USED IN COMPUTING THESE ANOMALIES (Airy-Heiskanan, Hayford-Bowie,

Vening-Meinesz, etc.) and also the assumed normal thickness of the continent.

MINOR CORRECTIONS

In computing the free-air and Bouguer corrections we assumed that the sea level corresponds to the surface of a theoretical earth model, the international ellipsoid. In reality, the surface of the sea is an irregular surface, called a geoid. To compensate for small differences between the geoid and the international ellipsoid, a small CORRECTION FOR INDIRECT EFFECT is needed.

In computing the Bouguer correction, we assume an infinite horizontal slab; that is, we neglect the curvature of the earth. A small CURVATURE CORRECTION may compensate for this approximation.

The free-air correction compensates for the normal vertical gradient. But the gravity effect of a SUBSURFACE GEOLOGICAL STRUCTURE is also less at the top of a hill than at sea level. A correction for the ANOMALOUS VERTICAL GRADIENT may compensate for this difference.

The corrections for the indirect effect, for the curvature of the earth, and for the anomalous vertical gradient are usually very small and in practical surveys they may be safely neglected.

About the Author

Raoul Vajk, a native of Hungary, studied mechanical engineering in Budapest, and later received a Ph.D. in cosmography at the University of Sciences in Budapest. From 1928 to 1931, he was geophysical interpreter with Torsion Balance Exploration Company, Houston. Vajk was head geophysicist of MAORT, Standard Oil Company (New Jersey) affiliate in Hungary from 1933 to 1946. Since then he has been in Jersey Standard's home office in New York City. In his present position as associate geophysical advisor he is mainly concerned with foreign exploration work.

Continued from Page 142

low aluminum sources of silicon dioxide of a particle size usable in oil-well cements are silica flour, which is mined in southern Oklahoma, and diatomaceous earth. Of these two materials, silica flour requires less water. Silica flour is recommended for cements where density requirements are 14.5 ppg or greater. For the lighter cements, it is necessary to use diatomaceous earth with its capacity for larger amounts of water, with the realization that certain sacrifices in strength must be made. Slow-set cements rather than portland cements were used as starting materials for the deep cement jobs in Pecos County because of their low tricalcium aluminate content.

Water-loss control is important for any cement slurry but becomes a must for deep-well cementing and, generally speaking, for most successful squeeze-cement operations. Inasmuch as more water is retained in a low-water-loss-cement slurry, the water-to-cement ratio is more constant and the thickening time is more predictable. Reliable thickening times are a necessity in deep-well cementing. As a cement slurry loses its water, it becomes viscous. Higher pump pressures are then required to keep the slurry moving. These increased pump pressures may in turn rupture the formation resulting in lost circulation.

Also, viscous and drier cement slurries have a greater tendency to channel because they do not flow as readily as a slurry containing the proper water-to-cement ratio. Severe water loss from a cement slurry can result in a flash set. Flash sets do not normally occur because of good mud cakes. Occurrence of a flash set when cementing in an extremely deep well could result in loss of the well. Use of a low-water-loss cement on any well will result in increased fill-up because of the small amount of water lost from the slurry during placement behind the casing.

The use of CMHEC in cement has resulted in the development of a new squeeze-cementing technique. Because of its success, the technique is in common use in some areas. It was reasoned that the use of a low-water-loss cement on anticipated high-pressure squeeze jobs would minimize dehydration of the slurry permitting the entire interval of perforations to be covered. Initial pumping rates are held somewhat lower than on conventional squeeze jobs.

Hesitation pumping may be necessary to obtain the desired squeeze pressure. If the desired pressure is not obtained, cement is left opposite the perforation rather than over-displaced. This method allows the use of larger volumes of cement without the danger of premature dehydration at the perforations and the resulting necessity to attempt to reverse out the major portion of the cement. Excessive thickening times are of no disadvantage as long as good squeeze pressures are developed. On the contrary, they allow more working time to insure safe placement and a successful job.

TO BE CONTINUED

About the Authors

Woodson **Fulton**

J. O. Woodson received his B.S. degree in mechanical engineering from the University of Tennessee in 1948. Following graduation he was employed by Phillips Petroleum Company in Bartlesville as a mechanical design engineer. He served in this capacity for two years. He was then assigned as a staff engineer in various production districts during 1950-56, including two years in Minden, La., and three years in Alvin, Texas. He was promoted to district engineer for Phillips in Odessa, Texas, in 1956 and then to his present position of division engineer in Midland in 1957.

C. L. Fulton attended University of Oregon and received his degree in education from the Oklahoma State Teachers College. He was employed by Halliburton Oil Well Cementing Company in 1940. He has held consecutive jobs with Halliburton as a driver, cementer, tester, special tools operator, and credit manager in Louisiana, Texas, Rocky Mountains and Kansas. He has held his present position of assistant division manager for Halliburton in Midland since 1955. He is a member of AIME, API and AADOC.

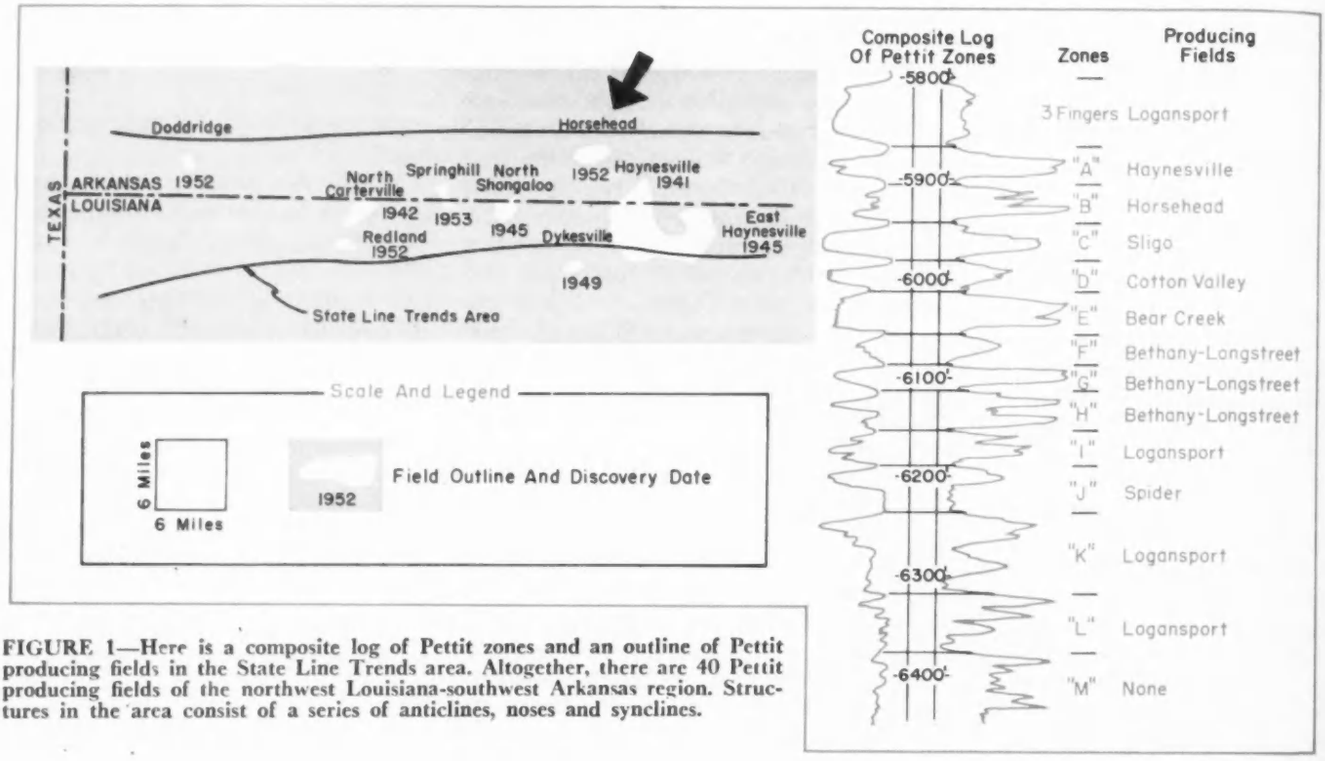

FIGURE 1—Here is a composite log of Pettit zones and an outline of Pettit producing fields in the State Line Trends area. Altogether, there are 40 Pettit producing fields of the northwest Louisiana-southwest Arkansas region. Structures in the area consist of a series of anticlines, noses and synclines.

In Horsehead field, Arkansas . . .

80-acre spacing sufficient to deplete primary oil

Primary recovery from this Pettit lime reservoir is estimated at 24 percent of original oil in place. Wide spacing also used in water flood operations now in progress

By Paul R. Waddle, Petroleum Engineer
Brookings, Moffat and Waddle, Shreveport, La.

THE HORSEHEAD FIELD Pettit lime reservoir, Columbia County, Arkansas, owes its profitable primary recovery status and its current favorable secondary recovery prospects to the fact that the field was developed on an 80-acre well spacing pattern. The thin pay zone and resultant low per acre recoveries coupled with relatively high well investment costs dictated discard of conventional 40-acre spacing in favor of 80-acre spacing in order to realize economic exploitation of the field. The 80-acre development program has effected efficient and economic recovery of the primary reserves and now is serving satisfactorily for water-flooding of the reservoir.

Geology. The Horsehead-Pettit reservoir is a member of the Sligo formation, a series of alternating beds of limestone and shale of Lower Cretaceous age. The Sligo formation, which ranges up to 700 feet in thickness, is divided into three members. The upper 50 feet is called the 3-Fingers lime while the balance is divided into the Upper and Lower Pettit, in which some 13 zones have been correlated and identified. Of these zones, the Upper Pettit contains 5 zones, "A" through "E", while the Lower Pettit contains 8 zones, "F" through "M" (Figure 1). There are 40 Pettit producing fields of the

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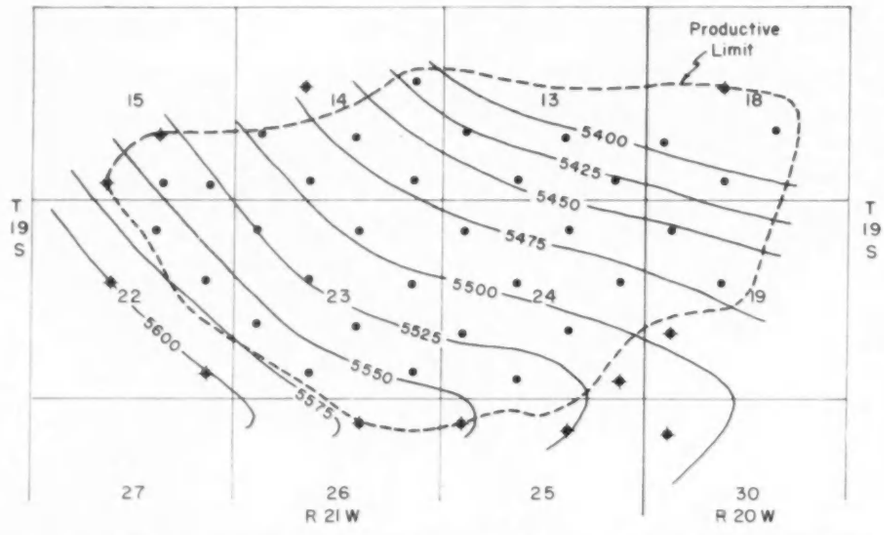

FIGURE 2—Development of the Horsehead Pettit reservoir is on the northeast flank of a low, with no apparent structural closure. This structural map was drawn on top of the Pettit lime at a contour interval of 25 feet.

northwest Louisiana-southwest Arkansas region. The Horsehead Field is in the State Line Trends area.

In this area, zones "A", "B" and "D" have well developed limestone trends that extend for a distance of 60 miles in an east-west direction along the Arkansas-Louisiana boundary (Figure 1). The structures in this area consist of a series of anticlines, noses and synclines that parallel each other in an east-west attitude. Nine commercial fields have been discovered in this area. Most of these fields are located on the axis of the nose but the productive limits are controlled principally by porosity-permeability pinchouts and facies changes.

The Horsehead Field produces from the second or "B" Zone of the Pettit at an average subsurface depth of 5,850 feet. Four intervals of porosity exist in the "B" Zone in most Horsehead Field wells. The third interval, from upper to lower, is the most extensively developed throughout the field and constitutes 84 percent of the field's total productive volume.

The Horsehead-Pettit producing zones are oolitic, fossiliferous limestone and oil accumulation is due to a permeability-porosity trap. Development is on a northeast flank of a low, with no apparent structural closure as shown in Figure 2. The productive limits, approximating one and one-half miles north to south and three miles east to west, cover some 2,600 acres. Effective pay thickness averages about 5½ feet. Porosity is about 19 percent while permeability and connate water average 120 millidarcys and 16 percent, respectively. No oil-water contact has been indicated.

Development. The Horsehead Field was discovered in February, 1952, on recompletion of a dry test in the underlying Smackover limestone. The discovery well was completed for an initial flowing potential of 84 bpd of 38 gravity oil with no water, through a 14/64-inch choke. The field was drilled on 80-acre spacing since the 40-acre spacing pattern conventionally used at this time in fields of this depth and nature was economically unattractive due to low per acre recoveries from the prevailing thin pay zones.

In the course of development, 45 wells were drilled. Thirty-three of these wells were producers. Five and one-half inch casing was set through the Pettit in each well. As a general rule, all existing porosity intervals were perforated for production and wells were stimulated initially with acid.

Production history. Initial state well allowable was set at 100 barrels per day. Prorated daily well production has varied from 100-72 barrels while the maximum allowable gas-oil ratio

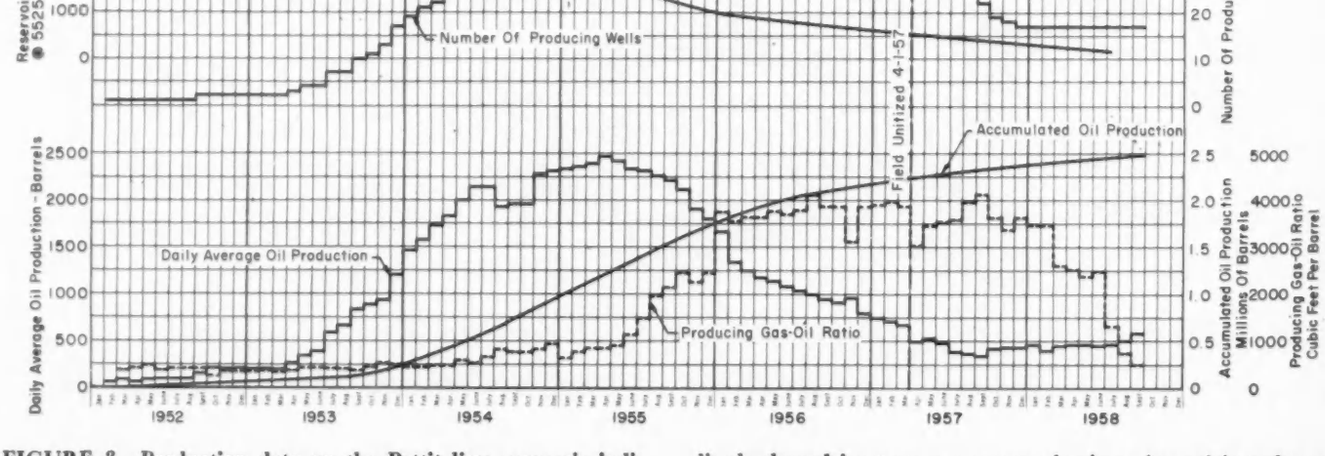

FIGURE 3—Production data on the Pettit lime reservoir indicates producing trends have followed the expected course for dissolved gas drive type recovery mechanisms. As anticipated, producing GOR's have decreased in the late stages of primary life.

was set at 2,000 cubic feet per barrel, above which production penalties were imposed by the State.

The primary recovery mechanism is dissolved gas drive as reflected by reservoir behavior characteristics. Also, the reservoir closely approximated typical dissolved gas drive behavior over a large portion of its primary life. The 38 gravity oil, under an original reservoir pressure of 2,460 psig, contained some 450 cubic feet of gas in solution per barrel of surface oil. No free gas was present originally and no evidence of a water drive has been noted. A peak oil production of 2,458 barrels per day was reached in April 1955, after which the wells experienced a rapid decline in productivity with an accompanying increase in gas oil ratios and a decrease in reservoir pressure. These production trends have followed closely the course expected for dissolved gas drive type recovery mechanisms. Production statistics are plotted in Figure 3.

A reflection of the adequacy and efficiency of the 80-acre spacing pattern to deplete the reservoir, is the field static pressure map of January, 1956, shown in Figure 4. An areally weighted average field pressure of 960 psig existed at that time. This was a decline of 1,500 psi from the original reservoir pressure of 2,460 psig. The reservoir was in substantial pressure equalization throughout the field. Pressure values ranged from 740 to 1,050 psig; pressures were somewhat lower than average in the thinner sections around the edges and higher in the thicker center areas of the field. Since reservoir pressure is a function (in this type recovery mechanism) of the degree of depletion, the comparatively uniform pressure drawdown prevailing throughout the reservoir in January, 1956, provides concrete evidence of the ability of the 80-acre well spacing to effect complete drainage and depletion of the reservoir. By projection of production trends, primary recovery is estimated at 24 percent of the original oil in place, or 2.7 million barrels.

It soon was recognized that the reservoir was a good candidate for water-flooding. On completion of reservoir studies by geologic and engineering committees investigating a

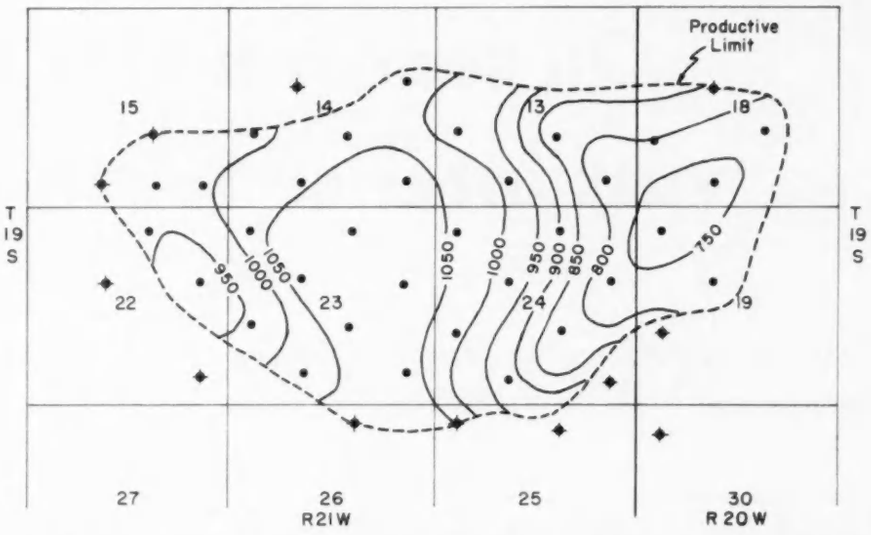

FIGURE 4—This static pressure map of Horsehead field's Pettit lime reservoir indicates a uniform pressure decline. Here, the average field pressure is 960 psig, a decline of 1,500 psi from the original reservoir pressure. The uniform draw-down illustrates the effectiveness of the 80-acre spacing employed in this field.

field-wide unitized water flood, a majority of operators and royalty owners elected to unitize the field for water-flooding. Accordingly the field was unitized on April 1, 1957. As of that date, the field's total accumulated oil production amounted to 2.2 million barrels. This represented 83 percent of the estimated primary recovery. The oil production rate was 668 barrels per day and water production was nil. Sixteen producers have been converted to water injection wells on an alternate basis. Using the remaining seventeen producing wells, the field is employing a 160-acre, 5-spot flood pattern.

As of October 1, 1958, production from the field totaled 2.5 million barrels representing 93 percent of primary reserves. Water injection was started in late 1957, and thus far 2.2 million barrels have been injected. Make-up water source is the fresh water Sparta formation found at a subsurface depth of 300 feet.

The flood is in its early, transient stages and initial production gains have appeared only recently. Production rate for September, 1958, averaged 591 barrels per day, compared with a low of 335 barrels per day during September, 1957. Reservoir pressure had dropped to a low of 185 psig in July, 1958. As anticipated, the producing gas-oil ratio has continued to decrease in the late stages of the primary life, averaging 522 cubic feet per barrel in September, 1958, as compared with a maximum of 4,142 cubic feet per barrel in September, 1957 (see Figure 3).

The rather sharp decrease in gas production and gas oil ratios experienced in August and September, 1958, concurrent with the appearance of the initial flood gains, is a phenomenon often occurring at this stage of water-flooding. Such GOR behavior may be associated with the fact that at this juncture the free gas saturation in the reservoir resulting from withdrawal of primary recovery oil as been replaced essentially by injected water, this condition leading to flow in the reservoir and consequent production, of a minimum volume of free gas. Also, it is common field experience that in 5-spot flood patterns as used in Horsehead, the first oil rate increase occurs when about one-half or more of the reservoir gas space has been filled with injected water.

Flood life is predicted to be some eight years with 16 million barrels of water, or 1.5 reservoir pore volumes, being injected. Continuation of water-flood operations to abandonment is estimated to lead to a total field oil recovery of 4.0 million barrels, which would give a gain due to water-flooding of 1.3 million barrels or a 48 percent increase over the primary recovery. **—The End**

Oil search under way in vast interior South America

Geology of sedimentary areas in Brazil, Bolivia and Peru becoming better known

This is the third of a series of four articles on the geology of the marine basins of South America. The first, tracing the movements of ancient seas, was published in the September 1959 issue of WORLD OIL. The second, discussing oil prospects of Argentina, Uruguay, Paraguay, and Chile appeared in October. This article describes oil prospects and geology of Brazil, Bolivia and Peru.

By Carl A. Moore
Chairman, School of Geological Engineering
University of Oklahoma

OIL POSSIBILITIES OF Brazil, Bolivia and Peru have scarcely been scratched. Remoteness of most of the prospective area of these countries has held back devlopment, but much has been learned of the geological conditions in many areas to guide present and future oil hunters.

BRAZIL

The largest country in South America illustrates many phases of petroleum exploration and development: untracked and unexplored jungle and grass lands in known sedimentary basins, preliminary reconnaissance by photogeology, detailed reconnaissance, geophysics, drilling of exploratory and stratigraphic holes and the development of producing areas. Development is being carried out by Petróleo Brasileiro S. A., (Petrobras), oil agency of the Brazilian government.

There are three producing areas in Brazil, one of which was indicated in 1957, and much unproved but potential area for exploration. First production was found in 1940. To Jan. 1, 1959, total crude oil production was 39,439,000 barrels, with a production of 18,923,738 barrels during 1958. Recoverable reserves by primary means are estimated at 250 million barrels.

Bahia (Reconcavo) Basin. (FIGURE 1) There is little oil production in Brazil outside of the Reconcavo area in the Bahia Graben. Total sedimentary section here is approximately 15,000 feet, in an area of a little over 8,000 square miles. Oil is produced from the Cretaceous, notably the Sergi sandstone member of the Brotas formation of lower Cretaceous age at depths of 2,000 feet to over 5,000 feet. Initial discovery was on the basis of surface geology and a few oil seeps. Later exploration has been augmented by seismograph. Some wells produce on structures while others produce from stratigraphic traps.

The largest field is Agua Grande, located 37 miles north of Salvador. This field produced more than 33,000 barrels of oil per day in September 1958, from the Sergi sandstone and the Ilhas formation.

Future. Crude oil production from Bahia has increased rapidly. Significant discoveries in recent years include the following:

- Dao Joao field was extended offshore, adding 40 producing wells to the field
- Additional development of the southwest area of the Candeias field, with the addition of some offshore wells
- New completions in the Agua Grande Field
- Discovery of oil in the Alianca formation below the Sergi sandstone
- A new oil field was discovered in the Pedras area

Northeastern coastal plain. Marine, mixed and nonmarine sediments occur in a narrow band along the coast north of Bahia in the states of Sergipe, Alagoas, Pernambuco, Paraiba, Rio Grande do Norte and Ceara.

The geological section is similar to that in the Bahia Graben, with some differences. Cretaceous sediments are underlain by older Mesozoic (Triassic?) rocks along the São Francisco River. Total sedimentary thickness is in the order of 6,000 to 7,000 feet. Very few surface indications of petroleum have been reported, although several wells which were drilled for salt have reported oil and gas shows.

During 1957, two oil wells were drilled near the coast in south Alagoas, near the Bahia Graben. Reports in-

FIGURE 1—Generalized Sedimentary Section, Bahia (Reconcavo) Basin

Tertiary	Barreiras formation	Sandstone, shale, conglomerate
	Ilhas formation	Sao Sebastiano sandstone Oolitic brackish limestones. Green shales, siltstones, sandstones.*
	Candeias beds	Shale. Basal sandstone.*
Cretaceous	Itaparica beds	Marine shales, few sandstones.
	Brotas[1] formation	Sergi sandstone.* Alianca sandstone.*
Pre-Cambrian		Basement.

* Oil-producing horizons.
[1] Possibly of Jurassic age, according to Walter Link.

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dicate a thin producing sandstone probably in the lower part of the marine Cretaceous section that tested at varying rates of crude oil production. A stratigraphic drilling program was under way in 1959 to determine the discovery's worth.

Maranhão Basin. (FIGURE 2) This is a large sedimentary basin, covering more than 235,000 square miles. It contains a thick oil-prospective Paleozoic section. Total sedimentary thickness is about 6,000 feet, with 3,800 feet being Paleozoic (mostly Devonian) and the remainder being Cretaceous and post-Cretaceous sediments. There appears to be a definite basinward thickening, with sediments becoming less sandy toward the center of the basin.

Paleozoic sediments are shallow marine and mixed, while the Cretaceous and post-Cretaceous are largely non-marine. So far, no production has been proved in this basin, despite the presence of favorable source and reservoir rocks.

Lower Amazon area. (FIGURE 3) The lower Amazon area lies between the Amazon Delta on the east and the city of Manaus on the west. On the north it is bounded by the Guiana shield area, and on the south by the Brazilian shield. It covers almost 95,000 square miles.

Sediments range in age from Cambrian(?) sandstones to Pennsylvanian shales, sandstones and fossiliferous limestones. These Paleozoic rocks outcrop on both sides of the Amazon River in proper sequence. Overlying the Paleozoics in places is pre-Cretaceous diabase varying up to 325 feet thick. A thin mantle of upper Tertiary to Recent which covers most of this broad area lies above the diabase.

Structurally, the Amazon area is an elongated syncline or a trough whose center lies approximately along the river. Recent geophysical exploration has located structures within the syncline. The Nova Olinda wells, 160 miles south of Manaus, found production in lensing sandstones of middle Devonian age, at depths below 9,300 feet. These wells have been abandoned. However, a sandstone above the original producing sandstone has shown good porosity and permeability with oil shows.

Due to numerous diabase dikes and sills in the Devonian rocks, seismic interpretations are often difficult. Additional well control, related to further geophysical data, may yield sufficient results to continue a high level of exploration here. Currently around 60 percent of the exploratory effort of Brazil is being conducted in this area, with many exploratory wells to be drilled. It is expected that further seismic work will be conducted further up the Amazon where less diabase is believed to be present.

FIGURE 2—Generalized Sedimentary Section, Maranhão Basin

Tertiary	Undifferentiated sandstones. São Luis sandstones. Pirabas (Miocene) argillaceous limestones.
Upper Cretaceous-Tertiary	Itapecuru formation. Boa Vista and Serra Negra sandstones and shales.
Cretaceous	Codo shale with limestone nodules. Corda sandstones, shale stringers.
Jurassic	Diabase.
Juro-Triassic	Pastos Bons formation. Sandstones with blocky limestone lenses.
Permian	Pedra de Fogo formation. Cherty limestone, shale, and sandstone. Gypsum in western part of basin.
Carboniferous	Piaui sandstones and limestones. Poti shale and sandstone.
Devonian	Rio Longo shales and sandstones. Cabecas sandstones. Pimenteiras shale and sandstone. Sierra Grande sandstones and shales.
Pre-Cambrian	Igneous and metamorphic.

FIGURE 3—Generalized Sedimentary Section, Lower Amazon Area

Cretaceous-Tertiary		Mantle
Jurassic (?)		Diabase
Pennsylvanian	Middle	Itaituba shales and siltstones; few evaporites; beds of fossiliferous limestone; massive sandstone at base.
Devonian		Erere shale, few beds sandstone. Curua shales, few beds limestone and sandstone. Maecuru sandstone.
Silurian		Trombetas sandstone.
Cambrian?		Uatuma arkosic sandstone.
Pre-Cambrian		Basement rocks.

Paraná Basin. The Paraná Basin covers about 465,000 square miles in Brazil, in addition to large areas in Argentina, Uruguay and Paraguay discussed under Argentina (Part 2 of this series). Exploration is continuing in this basin, despite the thick diabase section above prospective sedimentary strata.

According to Walter Link, Devonian, Carboniferous and Permian sediments underlie the Botucatu sandstone, considered to be of Triassic age (based mostly on vertebrate fossil evidence). The Botucatu is a tar sand over a large area, particularly in the State of São Paulo.

At least 20 distinct lava flows reaching a total thickness of 5,300 feet apparently rest on the Botucatu sandstone. Link dates these flows as Jurassic, instead of Triassic as described in this series of articles.

Acre territory—upper Amazon. This is a Cretaceous-Tertiary basin possibly underlain by Jurassic and Paleozoics. Little is known of its prospects. It falls in the Andean Geosyncline, lying west of the Asunción-Corumbá-Iquitos Arch. Discussion of it is more appropriate in connection with eastern Peru.

BOLIVIA

Current interest in Bolivia is found in the sub-Andean belt just east of the mountains and in the immediately-adjacent plains. Geological and structural conditions follow very closely the asymmetrical type basin as proposed by Weeks (1952). The Andes Mountains make up the borderland area on the west, and the sediments thin eastward onto the Brazilian shield area. It is noteworthy that the trough of the sub-Andean Basin narrows through Bolivia.

Initial production was proved in Bolivia in 1929, following surface geological mapping. To Jan. 1, 1959, total production was 21,832,000 barrels of oil. Reserves are estimated at 75 million barrels.

The sub-Andean sedimentary Basin in Bolivia (FIGURE 4) contains a continuous marine sequence from upper Cambrian (?) through Ordovician, possibly continuing into Silurian. These lower Paleozoics are dark

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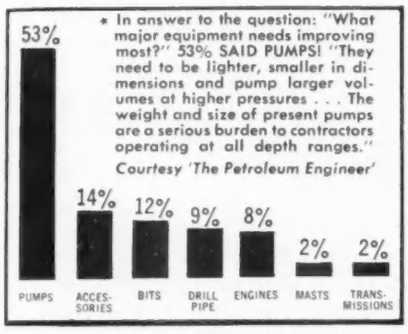


* In answer to the question: "What major equipment needs improving most?" 53% SAID PUMPS! "They need to be lighter, smaller in dimensions and pump larger volumes at higher pressures . . . The weight and size of present pumps are a serious burden to contractors operating at all depth ranges."
Courtesy 'The Petroleum Engineer'

There is no need to haul around all that dead weight, it costs money to move. A chain and sprocket is about half the width of a gear of equal torque capacity, and so is much lighter in weight than a gear drive. A Wilson Titan Pump weighs about 28 pounds per horsepower rating, while the average weight of 12 pumps in the same class is 56 pounds per horsepower. A Wilson Giant Pump weighs about 33 pounds per horsepower, but the average of pumps in its class is still about 47 pounds per horsepower.

Less space too: Since the chain and sprocket drive is less weight, it stands to reason that the pump is smaller. And any part of the pump is completely accessible.

Crankshafts: Old fashioned pumps have eccentrics, instead of true cranks. And these manufacturers will tell you that a crankshaft cannot be built which will not break. Wilson has never broken a crankshaft, in five years of operation. The Wilson crank is U. S. Patent Number 2,899,742.

How's 100 S.P.M. for speed. This is where the proof of the design pays off. Volume and pressure are the answer to any real questions regarding the pump operation. Following this paragraph are a few instances of how Wilson pumps do operate.

100 Strokes a Minute: Working in the rugged mountain desert country south of Farmington, New Mexico, the Summit Drilling Company is using a Wilson Giant 7½ x 14" Slush pump drilling to the Bisti Formation. Under everyday operations the pump is equipped with 5½" liners, holding 1050 pounds pressure, *at 100* strokes a minute. Frankly, we never heard of anyone running a slush pump this fast before, but seeing is believing. If you doubt our word on this, and frankly, we would doubt most anybody on such a statement, call Reese Williamson at Farmington, New Mexico, Davis 5-5714. Reese and his partner, Tom Cotton have cut about two days off the drilling time on these wells with the Wilson Giant Pump.

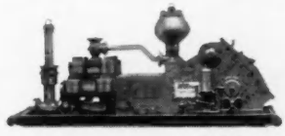
Take out that knock, too: It goes without saying, that such a record would not be possible without a Wilson Suction Flow Equalizer on the intake of the pump. Without this apparatus, the pump would pound like a moving loaded box car with a flat wheel. It took several years of research to develop the Suction Flow Equalizer, along with the revolutionary design of the Wilson Pump. But now that we have this device, we can greatly increase the speed of a pump, thereby reducing the weight per horsepower. You could not drive an automobile without springs and shock absorbers, except at very slow speeds. Similarly you cannot drive a pump at high speeds, without absorbing the terrific impact of the mud as it hits the end of the pistons and the valves. Modern drilling calls for high pressures, held at smooth levels.

What about efficiency? The Wilson Pumps have a completely streamlined fluid end, which makes the rapid flow of the mud easier. Also a chain drive does not take nearly as much horsepower as a gear drive. Any engineer can consult his handbook to prove this. So, we find that with the same horsepower, the pump either produces an average of about 15% more pressure, or about 15% more vacuum on the engines. Frankly, we think this is also caused by the smooth flow of the mud induced by the Suction Flow Equalizer operation. But anyway, it always happens, with either a corresponding reduction in fuel costs, or an increased rate of bit penetration.

Saves $1,500.00 per well. Back in December, we had a letter from one of our Contractor Customers at Oklahoma City, Pete MacKellar, who reported that the Wilson Giant Pump "With the two days savings on time, plus the fact that we have 20,000 pounds less weight to haul, has enabled us to make an estimated saving of $1,500.00 per well." Pete's phone at Oklahoma City is Regent 6-5261, if you want to know just how well his Wilson Giant Pump runs.

Contractor buys four Wilson Giant Pumps: One of the most active contractors in the business right now is the FWA outfit of Wichita Falls. We know this group is right in our back yard, but they are a bunch of operators with plenty of savvy in how to run a drilling rig. They run their four Wilson pumps at 75 to 85 strokes a minute most of the time, with pressures at about 1750 pounds. As one of their veteran toolpushers says, "It's the smoothest operating pump that our crews have ever used."

Pump on world's deepest slim hole: In the March 1959 issue, "Petroleum Engineer" carried an article entitled "The World's Deepest Slim Hole." A Wilson Titan 8" x 18" pump was used almost exclusively on this well.



Mud pressures ran to 3500 pounds for many days. The mud weight was about 19 pounds to the gallon. Try this out on your pump, and see how it performs! Most pumps for such service weigh twice as much as the Wilson Titan, but they pound at high speeds. Of course, if those pumps had a Wilson Suction Flow Equalizer, it would help them a lot.

Let's Look at the Cost: Wilson pumps cost about 65% of the amount charged for an ordinary slush pump of the same horsepower rating. Unfortunately most contractors today buy their pumps not on the quality of the pump, but on the amount of the trade-in they get for their old pump. Right now, there is a very poor market for *used* slush pumps. This puts the contractor in the position of taking an old fashioned product because he gets a high trade-in for his old pump. Then he is not able to compete price-wise against the users of Wilson pumps. No one would buy a 1940 model car *new* in 1959. Neither would a contractor buy a gear driven drilling rig. Why not buy a 1959 model chain driven pump on your next purchase and enjoy the quality and performance of a modern pump?

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shales, sandstones and/or quartzites. Overlying them is marine Devonian which is considered to be the source rock for Bolivian oil. Interbedded Devonian sandstones are reservoir rocks in Bolivia and northern Argentina. Glacial sediments are interspersed with some marine beds. Upper Cretaceous strata average slightly more than 1,000 feet thick. They are in turn overlain by a Tertiary mantle as thick as 9,000 feet.

Structures in the sub-Andean trough are elongated parallel to the mountain ranges and are often highly faulted. The oil fields are located on these elongated anticlines. Of the known oil seeps, the great majority are located along the sub-Andean belt, with the oil probably coming from Devonian rocks below.

Camiri field is the major producer in Bolivia, having yielded 17.2 million barrels of crude through the end of 1958. Current production is about 8,300 barrels daily from depths of from 1,480 to 6,600 feet. Primary pay horizons are of middle Devonian age. Commercial quantities of natural gas are produced also. Structure is an elongated anticline. In recent years the Guairuy field, located immediately southwest of Camiri, has entered production from Devonian at somewhat greater depths. Production statistics from the two fields are combined.

Other oil fields in Bolivia are Sanandita, located south of Camiri. Sanandita has produced more than 2 million barrels of crude from Permo-Carboniferous glacials. Production has declined in recent years. At the southern tip of Bolivia, adjoining San Pedro field in Argentina, is Bermejo field. Production is from the Permo-Carboniferous Tarija formation. Material shortages have hampered development of capacity production. Cumulative crude oil production is about two million barrels.

Some oil and natural gas production is indicated on Los Monos Anticline, located between Camiri and Yacuiba, in tight Devonian sandstones between 2,200 and 4,500 feet.

Geological and geophysical surveys along the sub-Andean trough have resulted in the mapping of more than 100 structures, of which 11 have been productive. Continued exploration should result in discovery of additional productive structures.

Northern Bolivia should become more important because the extensive middle Cretaceous sea deposited marine sediments in the area. Recent drilling has thrown some question on whether marine Cretaceous extends out of the mountains far enough to include feasible drilling terrain.

As the structures are located and tested along the sub-Andean trough, attention should be turned to the eastern part where sediments onlap onto basement rocks of the Brazilian shield. It is here that stratigraphic accumulation of oil should be found, as producing sandstones disappear eastward. This is a major area of interest for Bolivia.

PERU

Peruvian oil production began before 1890, and was the first in South America. Production rates have been essentially static since 1933, with a small increase during 1956.

To Jan. 1, 1959, Peru produced 540,750,000 barrels of oil, almost wholly from the northwest coastal area.

FIGURE 4—Generalized Sedimentary Section, Sub-Andean Basin of Bolivia

Tertiary		Non-marine shales, sandy shales.
Cretaceous		Shales, largely non-marine.
Permo-Carboniferous		Glacial sedmients. Tupambi sandstone at base**
Devonian	Middle	Marine sediments. Iquiri sandstone.**
Ordovician		Dark marine shales, few sandstones.
Cambrian?	Upper	If present, is probably dark marine shales, few sandstones.
Pre-Cambrian		Basement rocks.

** Major oil producing horizons.

However, oil is being produced from both sides of the Andes Mountains; along the coastal region in the Talara-Lobitos area, and in the eastern Montaña area in the sub-Andean belt. Reserves are estimated at about 400 million barrels of oil.

The Peruvian coastal fields show a great variation between fields and individual wells. This is attributed to the lenticularity of the Tertiary sandstones, and to the complex faulting. Production is from Eocene strata.

Relationship of oil accumulation to structure is one of the major problems in the Peruvian oil fields. Block faults with displacements of many hundreds of feet are common, while folding plays a minor role. Along the fault zones are irregular belts of crushed and broken rock. Each fault may be independent of adjacent faults. Dips and strikes of faults in the same locality may vary greatly.

Due to the density of faulting, oil has been enabled to migrate from a bed in one block into an adjacent bed of different age. In other words, oil may be jointly contained by two different age sandstones which are adjacent due to faulting. Shales and crushed zones also may act as trapping agents. Oil does not seem to be more abundant at the upper edges of a block, or in the middle, or against faults. On the other hand, a sandstone that lenses out within a fault block may trap an appreciable amount of oil. Such subsurface features give rise to oil fields of limited areal extent, producing large amounts of oil from a small number of wells.

Oil appears to have originated along the coast line in an open marginal basin in shallow marine waters. Succeeding deformation of the rocks by faulting, which accompanied the normal regional subsidence, has enabled oil to accumulate. Shales enclosing sandstones are believed to be the source rocks.

Depending on the structural position, production is relatively shallow, from an average of 2,000 feet in Zorritos field to about 3,000 feet in La Brea field. The latter field has produced almost 400 million barrels of 36° API gravity oil. Most of the producing wells are pumping. To the north, in the Lobitos, El Alto and Los Organos area, cumulative production exceeds 108 million barrels of crude.

Future of Northwest Peru. Much of the current production in La Brea-Parinas area has been maintained by secondary recovery (waterflooding). Future activity will entail expanding present producing areas, secondary recovery programs, and exploration in new areas in this

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FIGURE 5—Generalized Sedimentary Section, Northwest Peru

Pleistocene (some glacial)		Lobitos Talara. Mancora.	
Pliocene		Sechura.	
Miocene sandstones and shales	Upper	Tumbez.	
	Middle	Cardalitos.	
	Lower	Zorritos.	
Oligocene sandstones and shales	Upper	Heath.	
	Middle	Mancora.	
	Lower	Chira.	
		Verdun*	
Eocene sandstones and shales	Upper	Seman	Lobitos**
	Middle**	Restin Parinas.	
		Pale Greda Salina.	
	Lower	Negritos.*	
Cretaceous	Upper	Monte Grande, coarse sandstone. Copa Sombrero, dark shale. Pananga limestone.	
Jurassic		Granite intrusions.	
Pennsylvanian		Amotape slates.	

** Chief oil producing horizons.

FIGURE 6—Generalized Sedimentary Section, Eastern Peru

Tertiary		Ucayali non-marine. Contamana non-marine.
Cretaceous	Upper	Cachiyacu, shale and limestone. Vivian sandstone, plant remains. Chonta shale and limestone.
	Middle	Oriente group Huaya sandstone. Agua Caliente sandstone.* Raya. Paco sandstone. Esperanza dark shale. Aguanuya sandstone.
	Lower?	Cushabatay sandstone.
Jurassic	Upper	Sarayaguillo shale and sandstone.
	Lower	Pucara limestone.
Permian Pennsylvanian		Mitu group, largely continental, volcanics. Copacabana group, dark shale and limestone. Tarma group, shale and limestone.
Mississippian		Ambo group, sandstone, dark shale, coal.
Devonian		Cabanillas group.
Ordovician		Hualla Hualla series. Contaya shale and quartzite.
Pre-Cambrian		Marcapata formation. Araza gneiss.

* Oil producing horizon.
Note: Pre-Cretaceous rocks are described from sections in the mountains.

open marginal basin. In 1957, the government opened bidding for concessions on the continental shelf.

In the Montaña area or sub-Andean belt of eastern Peru is one of the major potential oil producing areas of South America. This area occupies the trough of an asymmetrical basin. Structures are to be expected on the borderland side of the basin, and stratigraphic traps should be encountered toward the east, where the sediments of the trough onlap onto the Brazilian shield basement rocks.

Marine Paleozoics, Jurassic and Cretaceous occur in eastern Peru (Figures 1 through 4 of first article of series). Thick Tertiary sediments are non-marine.

Because of the youth of the Andes uplift, the structures near the mountains are parallel to the mountain folds. Some illustrate various stages of weathering or dissection, and others stand high as topographic features. A number of these anticlines lie as far east as the Brazilian border and beyond. The Brazil-Peru boundary follows the crest of some of these anticlinal hills.

In 1939, Compañía de Petróleo Ganso Azul (80 percent owned by Texas Gulf Producing Company) tested one of these dissected anticlines along the Pachitea River, tributary of the Ucayali, which in turn flows into the Marañon near Iquitos. This location was some 3,000 miles up river from Belem (Para), Brazil, and 400 miles from Iquitos, Peru.

The 1-A Ganso Azul, drilled on the Pachitea River near Pucallpa, Peru, found production in the Agua Caliente sandstone member of the Oriente group at a depth of 1,150 feet. This field produces 2,500 barrels of oil per day from about 15 wells. The latest completion found production at 1,025 feet. Previous production had been limited by the refining capacity of 1,500 barrels per day at Iquitos. When the 5,000-barrels-daily refinery went on stream at Manaus, Brazil, in 1957, production was increased. Cumulative production from this field is more than one million barrels.

Latest success in the Montaña was during 1957 when El Oriente Company, a syndicate including West German interests, found production in the Maquia well near Contamana. This well tested 500 barrels of oil per day during March 1957, and was shut in. This is the first discovery in the Montaña of eastern Peru since 1939, and appears to be one of the most significant recent discoveries in South America. The second well was completed flowing about 260 barrels of oil per day.

The Texas Petroleum Company abandoned 3 deep exploratory tests on the upper and middle reaches of the Marañon River at total depths of 9,196, 9,787 and 11,537 feet respectively, with the third being plugged in February 1957. Location of the third test was some 75 miles southwest of Iquitos at the mouth of the Tigre River. This was the deepest test drilled in the Montaña.

Future. The Montaña (Oriente) area appears to have a very good future. Continued exploration will be carried out to test the many anticlines now known. Geophysics will be correlated with surface and subsurface geology to obtain as complete a picture as possible.

Active salt intrusions are known near Moyobamba, although the structural significance of these is not entirely understood.

A recent check showed an almost complete coverage of much of the Montaña area by concessions held by many companies. Oil production here will depend largely on pipe line facilities to move oil to the coast. A trans-Andean pipe line has been proposed from the Marañon River across the mountains to the Pacific coast.

Pirin field. In far southeastern Peru is the small, now abandoned Pirin oil field. It is located in a northwest-southeast trending syncline high in the Andes Mountains on the border of Lake Titicaca. Some 300,000 barrels of oil were produced from Cretaceous sandstones in shallow wells located near seepages along a fault at Pirin. Additional development wells failed to find commercial production. No future development is to be expected here.

A full list of references will be included at the end of Part 4 of this series of articles.

TO BE CONTINUED

What's Happening among MEN in the INDUSTRY

M. J. Davis

C. E. Reistle, Jr.

H. W. Ferguson

J. W. Brice

The Humble Division of the new **Humble Oil & Refining Company** has announced the proposed officers and Board of Management executives for the newly organized Delaware Corporation. **Morgan J. Davis,** president of the present Humble Company, has been elected to the same position with the newly organized corporation. **Carl E. Reistle, Jr.,** executive vice president of Humble of Texas, will be one of three executive vice presidents and a director; **H. W. Ferguson,** Humble vice president, will be a vice president and director of the Delaware Corporation. Other new officers include **John W. Brice,** executive vice president and director, Carter

R. J. Schilthuis

H. P. Pressler

W. Naden

E. D. Reeves

R. J. Gonzalez

Ray Horton

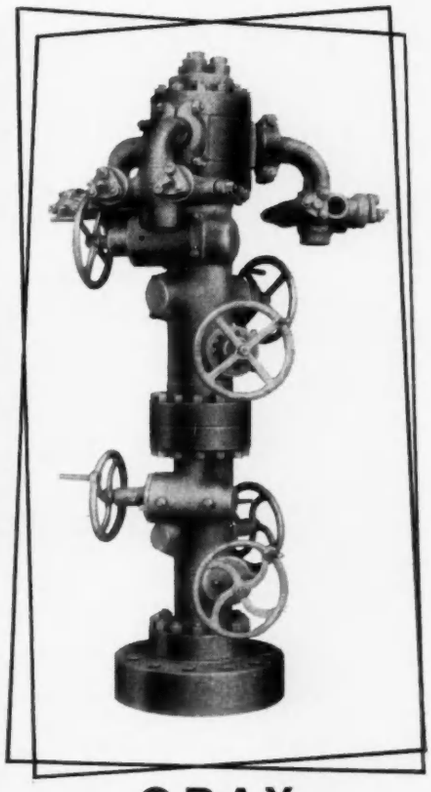
Oil Company; **William Naden,** executive vice president and director, Carter; **E. D. Reeves,** vice president and director, Esso; **Richard J. Gonzalez,** director and treasurer, will be coordinator of Finance and Economics; **Ray H. Horton,** vice president and director of Humble, will serve as president of the new Humble Division and will head its Board of Management; also on the board will be **Ralph J. Schilthuis** as executive vice president; **Herman P. Pressler** as vice president; **Ed J. Hamner, James H. Galloway** and **Russell H. Venn,** as members; **Carl Illig,** member and general counsel; **Nelson Jones,** presently general counsel, will be general counsel; **Oral L. Luper,** presently controller, will assume the position of controller. Others invited to join the new company are **G. B. Edwards,** presently controller of **The Carter Oil Company,** as head of the Tax Department; **L. J. Weigle,** manager of the Southern Division of Carter, to fill the position of secretary; and **Lester R. Moore,** treasurer of **Esso Standard Oil Company,** will become treasurer of the new company.

Dr. J. F. Mason, Karachi, Pakistan, has been appointed staff geologist in **Continental Oil Company's** Foreign Department, with headquarters in New York City.

William R. Evitt and **Peter H. Masson** have been named research associates in the geological research division at the Jersey Production Research Center, Tulsa.

Pan American Petroleum Corporation has announced the transfer of geologists **John J. Pedry** and **G. William Hurley** at Casper, Wyo., to Bismarck, N. D.

Robert Carlson, geologist at Del Rio, Texas, for **Shell Oil Company,** has been transferred to the firm's staff at Casper, Wyo.



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For field processing of oil and gas, the Parkersburg Indirect Heater offers that extra capacity that assures dependable production year 'round. The Parkersburg Indirect Heaters feature simple, rugged and accurate controls — blowout-proof burners and pilots — interchangeable coils in working pressures to 6500 PSI and higher. Special heaters with alloy-cast iron coils are available for production of highly corrosive sour crudes.

SPECIFICATIONS

Model No.	Nominal Shell Size	Furnace Input to Water (BTU/HR)	Nominal Tube Sizes (Inches)	Approximate Shipping Weight (LBS)
I.H. 90	1'6" x 6'0"	90,000	1, 2 & 3	700 - 800
I.H. 250	2'0" x 6'0"	250,000	2 & 3	1,500 - 1,700
I.H. 500	2'6" x 7'6"	500,000	2 & 3	2,400 - 2,700
I.H. 750	3'0" x 9'0"	750,000	2 & 3	3,100 - 3,800
I.H. 1000	4'0" x 10'0"	1,000,000	2 & 3	6,000 - 7,400
I.H. 1500	5'0" x 12'0"	1,500,000	2, 3 & 4	7,700 - 10,200
I.H. 2000	6'0" x 12'0"	2,000,000	2, 3 & 4	9,600 - 12,300
I.H. 4000	6'0" x 22'6"	4,000,000	3, 4 & 6	15,000 - 20,800

Coil Working Pressures: (2" Std. — 2000 PSI), (3" Std. — 1900 PSI), (1, 2, 3, 4 & 6 inch Extra Heavy — 3000 PSI), (2" Double Extra Heavy — 6500 PSI), (3" Double Extra Heavy — 6000 PSI).

See your **PARKERSBURG** Man Today

THE PARKERSBURG RIG & REEL COMPANY

Division of Parkersburg-Aetna Corp.

PARKERSBURG • HOUSTON • TULSA

PESA

The California Company has transferred **Robert Habart,** geologist, from New Orleans to Casper, Wyo.

Louis O. Lasiter of Tulsa, is the new state agent of the **Dawn Petroleum Company.**

Arthur Wucker, geologist at Grand Rapids, Mich., for **The Carter Oil Co.,** has resigned to join the **Don F. Rayburn** organization.

D. H. Scott

D. N. Klemme

L. B. Christian

L. F. Machesky

Anglo-Philippine Oil Corporation, Manila, Philippines, has recently announced the signing of contracts with each of the following American geologists. **David Holcomb Scott,** exploration manager, formerly with Hancock Oil Company and Signal Oil and Gas Company; **Daniel Norman Klemme,** chief geologist, formerly with Hancock Oil Company; **Louis Bernard Christian,** geologist, formerly with Standard Oil of California; and **Lawrence Frank Machesky,** geologist, formerly with Standard Vacuum Oil Company.

Ken Davis, Jr., president of **Kendavis Industries, Inc.,** International has assumed the duties as president of **Loffland Brothers** domestic companies with headquarters in Tulsa. Other changes within the company include the promotion of **J. O. Rundle** as president of all Loffland Brothers foreign companies, and **T. W. Wheeler** as executive vice president of Loffland Brothers domestic companies.

Ken Davis, Jr.

Esso Standard (Libya), Inc., an exploration and producing affiliate of **Standard Oil Company** (New Jersey), has announced the election of **Robert A. Eed** as president and director, succeeding **James A. Clark** who has retired. At the same time, **H. W. Brown,** a director and vice president of Esso Libya, was elected to the newly created position of executive vice president.

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MEET DEXTER WRIGHT
(an oil finder)

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With more than 26 years of continuous service and experience with Petty, Dexter Wright personifies the fact that you can depend on reliable, experienced crews from Petty.

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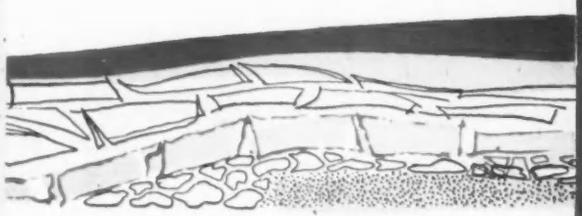
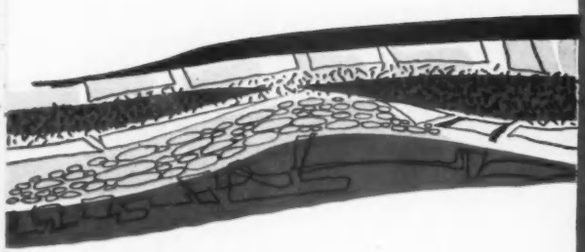
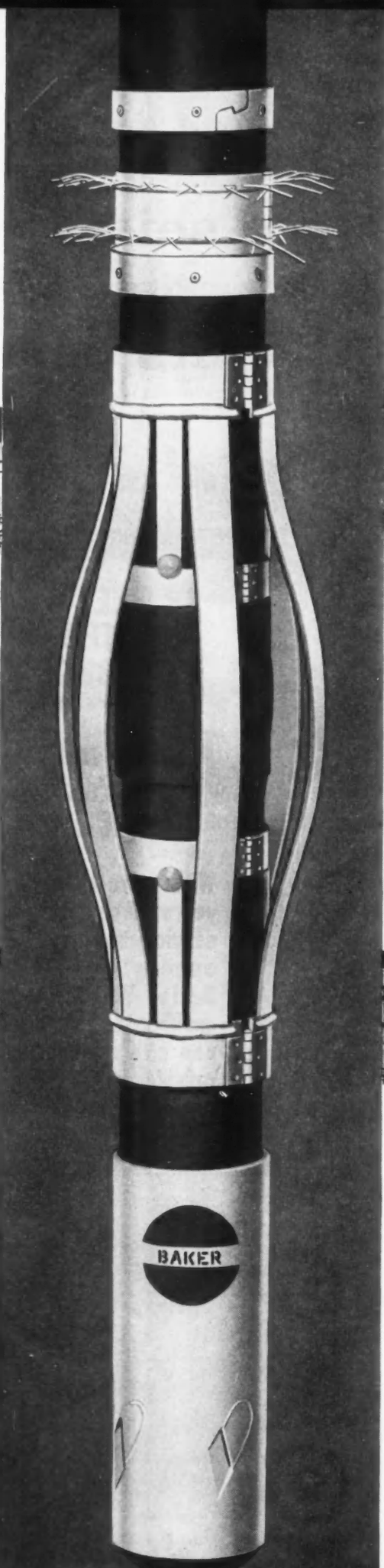


* *Casing on Bottom Safer and Faster*

* *Protection of Productivity*

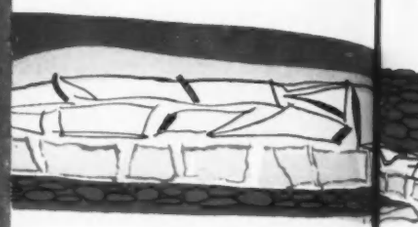


...Specify *BAKER* PRIMARY CEMENTING EQUIPMENT



Baker Wall Scratchers

HINGE-LOK or SOLID-RING Models for all popular casing sizes.



Baker Casing Centralizers

HINGE-LOK or SOLID-RING Models with Multiple Ranges for all popular casing sizes.

Baker Fill-Up Equipment

DIFFERENTIAL Shoes and Collars for *any* well, and economical FLEXIFLOW Shoes and Collars for wells of *moderate* depth.

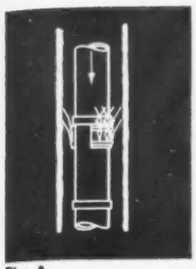


Fig. A

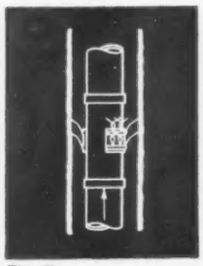


Fig. B

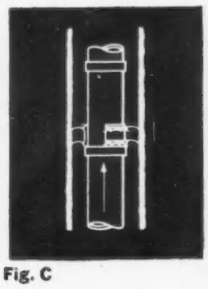


Fig. C

Fig. A Scratcher wires, retained by integral hinged mounting, swing freely upward and do not remove mud cake while running in.

Fig. B Even when casing is lifted out of the slips, the entire Scratcher remains stationary. Only when reciprocated, and

Fig. C ...only at the cementing area does the "scissors" action of the crossed wires remove mud cake.

Baker Scratchers remove mud cake only from the cementing area; this "controlled scratching" protects productivity.

While running in, the scratcher wires automatically swing upward along the casing, where they are safe from damage; permit free, unrestricted lowering of the casing; and do not disturb or remove mud cake. There is no danger of "balled-up" mud collecting on the scratcher wires to plug the annulus and contribute to pressure surges with possible "mudding-off" of the producing zone. Only when the cementing area is reached and the casing is reciprocated do the double rows of strong "crossed" spring wires automatically reach out, dig in, and remove the mud cake with efficient "scissors" action.

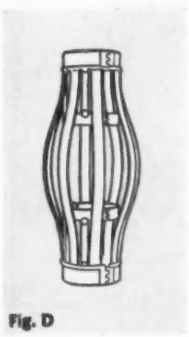


Fig. D

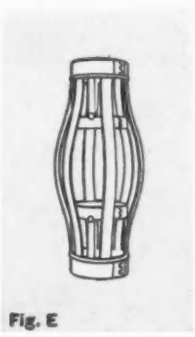


Fig. E

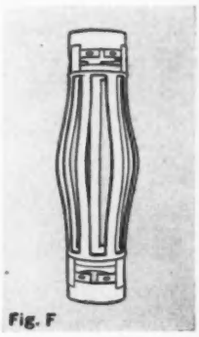


Fig. F

Fig. D "Extended" Range HINGE-LOK Baker H-25 Casing Centralizer. Product No. 9113.

Fig. E "Normal" Range HINGE-LOK Baker H-20 Casing Centralizer, Product No. 9112.

Fig. F "Slim Hole" SOLID-RING Baker G-15 Casing Centralizer, Product No. 910-G.

Baker Centralizers assure cementing clearance. "No-scrape" design prevents "balling", plugged annulus and stuck casing.

The QUALITY of Baker Casing Centralizers starts with "sled-runner" springs made of high quality spring steel—tested and pre-set by flattening in hydraulic presses—then butt-welded to collars to form a unit of great strength. Pre-setting of the springs to the pre-calculated optimum bowed height enables each centralizer to pass tight spots or dog legs without damage to the assembly, and ensures GREATER CENTERING FORCE for maintaining annular clearance for cementing.

Baker Centralizers do not remove mud cake which could plug the annulus, contribute to pressure surges and restrict productivity.

BAKER OIL TOOLS, INC.

Houston • Los Angeles • New York

Fig. G

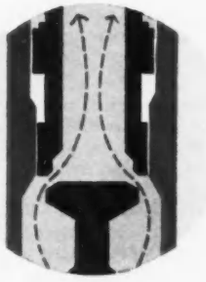


Fig. H

Fig. G Variable FILL-UP Valve as used in FLEXIFLOW Equipment.

Fig. H Variable FILL-UP Valve as used in DIFFERENTIAL Equipment.

Baker Fill-Up Equipment saves time in running casing, but does not create pressure surges that reduce productivity.

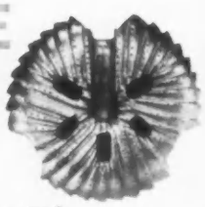
Destructive pressure surges—often created when casing equipped with conventional floating equipment is lowered into the well—can now be avoided. The Variable Valve in either Baker DIFFERENTIAL or Baker FLEXI-FLOW "Fill-up" Shoes and Collars, permits casing to fill from the bottom up; eliminates expensive, time-consuming surface filling; and automatically coordinates the *rate of fill* with the *rate of lowering* to AVOID high pressure surges. Baker FILL-UP Equipment permits the casing to be lowered at normal rates, saving rig time and reducing danger of sticking the pipe; chances for successful primary cementing are increased; formations are protected from high pressure surges which can impair their productivity.

HYCALOG V-DOOR DIAMOND DRILL BITS

PATENT PENDING

HYCALOG

INCREASES AVERAGE FT./HR. FROM 1½′ TO 5.7′ IN 7000 FT. CANADIAN WELL



In a recently completed hole in British Columbia a series of conventional rock bits averaged only from one to two feet per hour. The longest run was 31 ft. . . . the shortest 9′.

At this point a Hycalog V-Door was run. From 6709′ to 7229′, it averaged 5.7 ft./hr., a performance so unbelievable that the string was pulled to check on the bit. *Still in excellent condition*, it was rerun. The balance of the run to 7734′ was completed . . . also at an average of 5.7 ft./hr. . . . and the bit was still in good condition.

Let a Hycalog V-Door set a record on your next well. *And include* HYCALOG WELL LOGGING *and* DRILL FUNCTION RECORDING.

Hycalog, Inc.

505 AERO DRIVE
SHREVEPORT, LOUISIANA

BRANCH OFFICES IN PRINCIPAL OIL PRODUCING AREAS

DIAMOND BITS DIAMOND CORING
WELL LOGGING CORE ANALYSIS

Shell Honors California Oil Pioneer

One of California's most prominent oil pioneers, the late B. H. van der Linden of Shell Oil Company, was honored recently at Ventura, Calif., when a plaque was dedicated to him and the other early oil men whose perseverance led to the discovery of the 600,000-barrel Ventura Avenue field, one of the most prolific in the state. Unveiling the plaque are F. R. Schmieder (left) general production superintendent for Shell in Los Angeles, and O. W. Chonette, district production superintendent for Texaco Inc., in Ventura and president of the Petroleum Production Pioneers, sponsors of the ceremony.

August B. Small has been named a research associate by **Esso Research and Engineering Company.** The position of research associate is awarded to men with outstanding technical abilities.

Henry La Cossitt

Gulf Oil Corporation has named nationally known editor and one-time radio commentator **Henry La Cossitt,** its public relations representative in Washington, D. C. La Cossitt's responsibilities will be closely allied to a broad-based political program recently announced by Gulf. La Cossitt is a native of Shreveport, La.

William J. Rogers, assistant division production superintendent for **Sinclair Oil & Gas Company** at Fort Worth, has been promoted to assistant chief petroleum engineer in the general office of the Production Department, Tulsa. He succeeds **F. F. Wright** who has been named executive assistant in the Exploration Department. In his new post, Rogers is assistant to **Lloyd Holsapple,** chief petroleum engineer. **Russell D. Karns** has been named assistant treasurer of **Pan American Petroleum Corporation. The Arabian Oil Company** has announced the election of **W. R. Cooper,** general manager of engineering and construction, a vice president of Aramco.

Alfons Landa, chairman of the Board of **Reiter-Foster Oil Corporation,** and **Emil V. Hegyi** were elected to the Board of Directors of **Consolidated Oil Corporation** at the September annual meeting.

Cleo J. Gracey

Cleo J. Gracey has resigned his position with Gulf Oil Corporation in the geological department to become an independent consultant. Gracey will have offices in the **Bank of the Southwest Building** in Houston.

Richfield Oil Corporation has announced the appointment of **M. C. (Barney) Barnard** to its newly created position of chief scout for all Richfield's operations, with headquarters in Los Angeles. **William R. Horsley** replaces Barnard at Bakersfield.

a Name SYNONYMOUS with Quality

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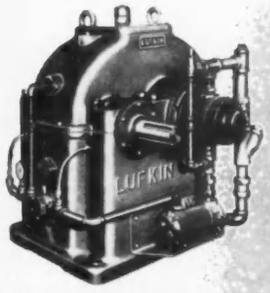
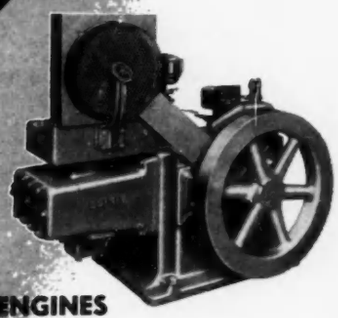


SPEED REDUCERS AND INCREASERS



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SPECIAL CLEARANCE TUBING COUPLINGS

Like all Anvil Brand oil field fittings, the special clearance coupling shown here makes up fast, saves time on-site. Consistently clean and accurate threads—electro-galvanized—are the reason. These special clearance couplings are painted overall according to A.P.I. color code; in addition, they bear a contrasting color band to indicate grade of string on which each should be used.

Anvil Brand Fittings—A.P.I. couplings for all regular oil field applications, bushings, plugs, and nipples— undergo scientific materials testing and continual gaging during manufacture. They are sold through your nearest supply store, whose engineering service to customers is supported by Anvil Brand Representatives in key locations. Write today for further information.

Home office and main plant: Allison Park, Pa. Anvil Brand Couplings are also manufactured by Anvil Products, Inc., Longview, Texas, and by Canadian Coupling and Fittings, Ltd., Simcoe, Ont., Canada.

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John B. Nunn

John B. Nunn has resigned from Sunset International Petroleum Corp., in Denver, to become an independent broker for oil and gas leases and production. Nunn, who was a vice president and director of McRae Oil & Gas until its merger with Sunset, will remain in Denver.

Herbert F. Defenbaugh, division production superintendent at Midland, Texas, for **Sinclair Oil & Gas Company,** has been elected vice president for production and has been transferred to Tulsa. Defenbaugh succeeds **F. H. Rhees,** vice president and director, who has been promoted to operations coordinator. **O. G. Simpson,** Tulsa, executive assistant in the Production Department to Rhees, has become division production superintendent at Midland.

Jed B. Maebius has been named manager of the Exploration Department of **Tidewater Oil Company's** Southern Division at Houston, replacing **T. G. Kelliher** who has been promoted to exploration manager for domestic operations in Los Angeles.

Texaco Inc., has announced the appointment of **S. A. Berthiaume** manager of the newly-created Exploration division, Domestic Producing Department of the firm. Berthiaume was an executive of the Texaco Exploration Company. **O. F. Sebesta** has been promoted to assistant general manager of the department; **J. W. Rawley** is the new division manager at Tulsa; **L. W. Calahan** is the new division manager at Dallas, and **L. F. Shiplet** and **G. H. Clark** have been appointed members of the general manager's staff.

W. W. Clawson of Dallas, senior vice president and director in charge of exploration, producing and research activities of **Magnolia Petroleum Company,** has been named manager of exploration for **Mobil Oil Company.**

The Department of Mineral Resources, Saskatchewan, announces the appointment of **Dr. W. P. Thompson,** past president of the University of Saskatchewan, to the provincial **Oil and Gas Conservation Board.** The vacancy was occasioned by the resignation of **Dr. J. W. T. Spinks,** who served as a member for seven years.

J. H. Cobbs

James E. Cobbs has established consulting petroleum engineering offices in the **Midstates Building,** Tulsa. Cobbs was formerly division reservoir engineer for Tidewater Oil Company. Cobbs plans to specialize in appraisals, valuations and field supervision in the Mid-Continent region of the United States.

H. P. Ashton has succeeded the retired **R. L. Inglish** as regional operating superintendent in the Southwest Division of **Sun Oil Company.** Ashton will continue to headquarter at Dallas.

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KINLEY TUBING PERFORATOR

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BEAUMONT, TEXAS
Assoc. Eng. & Eqpt., Inc.....TE 5-7046, ZF 8-2023
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Cameo, Inc.....CE 5-3124
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MIDLAND, TEXAS
Lucecus Service & Eqpt. Co.....MU 2-1631
HOUMA, LOUISIANA
Assoc. Eng. & Equip. Inc.....UP 2-0347
ODESSA, TEXAS
Cameo Wire Line Service, Inc.....FE 2-6497
OKLAHOMA CITY, OKLAHOMA
Rainbo Service Co.....ME 4-2131, ME 4-0105
PETTUS, TEXAS
Eddie Jones Eng. Co., Pettus 16, Beeville, FL 8-1218
SHREVEPORT, LOUISIANA—Cameo, Inc....8-3615
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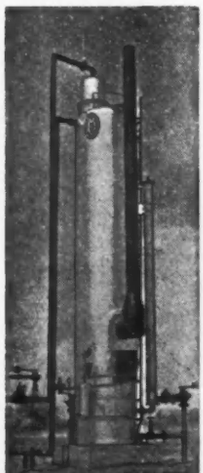

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Directional Drilling

Stops the trouble before it starts

Homco Directional Drilling is a service designed to give you the most accurate and most economical job possible. The skilled Homco operator working for you knows his job and has the tools to do it right. He is in constant contact with a staff of Directional Drilling experts who guide and check his operations.

One of the tools that the Homco man uses in directional drilling is the Homco Combination Jar and Keyseat Reamer. This tool, designed and manufactured by Homco, primarily for Directional Drilling, prevents many a stuck string. There is no better insurance against stuck drill collars in keyseats than this tool. With reamer blades larger than the O.D. of the collars, when keyseats are formed the tool sticks instead of the collars. When this occurs it is easy to rotate to the right to jar down and out of the keyseat. Then the string is raised, rotated to the right, and the tool reams up through the keyseat.

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THE WORLD'S LARGEST INDEPENDENT OILFIELD SUPPLY AND SERVICE ORGANIZATION

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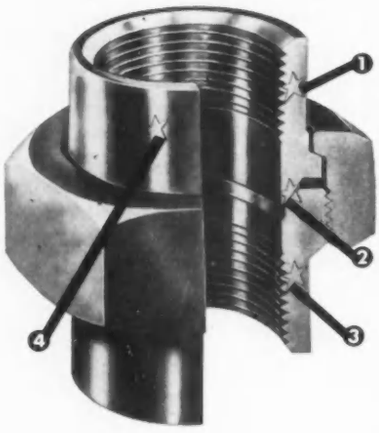

1. **Uniform walls** for even expansion and contraction under temperature changes. They follow the pipe!

2. **Catawissa Ball-to-Angle Seats** give you a "Perfect Seal" regardless of pipe alignment!

3. **More than adequate** wall thicknesses give you Catawissa's 3-to-1 Safety Factor (3000-lb. service, 9000-lb. test; 6000-lb. service, 18000-lb. test)!

4. **Round, straight barrels** for fast wrenching. No uneven or tapered surfaces to cause wrench slips or wrench locking!

Catawissa Perfect Seal Pipe Unions are made by Union Specialists from 80,000 lb. tensile strength steel (ASTM Spec. A-105-55T, Grade II). Steel forgings from our own forging mill are closely checked for imperfections . . . and finishing on modern, automatic machines with close inspection during and after production give you pipe unions second to none!

Write for Catalog 58 showing the complete Catawissa line of Perfect Seal Products.

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R. O. Rhoades

David Proctor

R. O. Rhoades, a director and executive vice president of **Gulf Oil Corporation,** has been elected to succeed **David Proctor,** chairman of the board of directors. Proctor has retired after 40 years with the Gulf companies. Rhoades, in addition to being a member of Gulf's Board, also is a member and vice chairman of the Executive Committee and a member of the Compensation Committee.

J. A. Rogers, former chief geologist of the Domestic Producing Department of **Texaco Inc.,** has been appointed assistant division manager of the New Orleans Division.

Harris Van Zandt has been appointed to the new position of general manager of **Pure Oil Company's** Exploration and Production division. He will headquarter in Chicago.

Robert L. Hoss, Denver, has recently established an office in the **Denver Club Building** as a petroleum consultant. For the past five years he has been associated with Vaughey and Vaughey, Denver, as director of drilling and production operations in the Rocky Mountains and Canada.

Howard A. Parker, Jr., assistant general manager of manufacturing for **American Oil Company,** has been transferred to Chicago to take a post with **Standard Oil Company (Indiana).**

Award to Nixon

Raymond Plank, president of Apache Oil Corp., presents an award to Vice President Richard Nixon on behalf of the Young Men of Minnesota, an organization which promotes individual interprise. The club, of which Plank is president, praised Nixon's actions during his recent trip to Russia.

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The New GLPS Plutonium *Beryllium Source Gives You:

A CLEAN Neutron Source, with CONSTANT Neutron Emission!

*Recently released by the Atomic Energy Commission for industrial use.

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GLPS will furnish an analysis curve, upon request, which will comply with the new A.P.I. logging standards

A porosity log of your well offers convincing proof of the superiority of the new GLPS Plutonium Beryllium Source. For further information or service, call your nearest GLPS Branch.

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For more data on advertised products, use Readers' Service Cards, last page.

Mohammed and his Ruston turbines

Mohammed ibn Rajih Mohammed, leading engine room operator, checks gauges on one of the two Ruston gas turbines at Nariya pump station which is on the pipeline system that transports oil from Aramco installations to the Tapline terminal at Sidon, Lebanon. Many Ruston gas turbines are now operating on Aramco's pipelines in Saudi Arabia.

To Nariya came two Ruston gas turbines . . . and Mohammed ibn Rajih Mohammed found himself in control of industrial power, in its most advanced form. But Mohammed, who is now leading engine room operator at the Arabian American Oil Company's Nariya pump station in Saudi Arabia, soon recognised the simplicity of operating a Ruston gas turbine . . . that's just one of many features of these turbines which have made them so popular with oilmen from the Middle East to the Americas.

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Representatives for Petroleum Industries in the U.S.A.: Beckley, Haltom & Hickman, The Americas Building, Rockefeller Center, 1270-6th Avenue, New York 20, N.Y.C.

Sinclair Oil & Gas Company has promoted **F. H. Rhees,** vice president and a director, to operations coordinator, a newly created post. Rhees will serve as coordinator for production, gas and gas products, liquefied gas products sales, engineering, property acquisition, part interest and motor transportation and mechanical maintenance.

F. H. Rhees

Continental Oil Company has announced the appointment of **Basil R. Littin,** Washington public relations man, as associate director of public affairs for the firm.

Carroll J. Brown has been named executive development advisor of **Standard-Vacuum Oil Company.** He succeeds **Lawrence C. Hamlin** who has been appointed regional vice president in charge of the company's Far East operations.

Falcon Seaboard Drilling Company has announced the transfer of **Ed Arnold.** Arnold moved his offices from Houston to the firm's head office in Tulsa. He will assume the duties of drilling engineer for the company's Mid-Continent area.

J. R. Pace

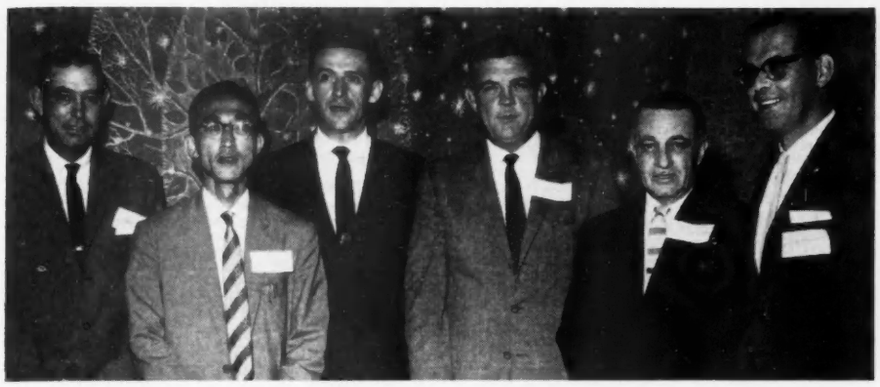
J. R. Pace has joined **Wireline Engineers, S.A., of Venezuela,** as vice president and general manager, with office in Las Morochas. Pace was formerly associated with the Humble Oil & Refining Company and the Creole Petroleum Corporation. He was most recently division reservoir engineer for Creole in eastern Venezuela.

Shell Oil Company has announced three staff changes in its Houston area Land Department. **W. R. Kemper** and **G. A. Koerner** have been named area land agents in Houston. They were previously division land managers in Corpus Christi and Houston, respectively. **R. S. Terry,** formerly land agent in the Houston area, has been named Houston Division Land manager.

International Drilling Company N.V., has announced a number of changes in personnel and office set-ups. **Monty R. Garrison,** managing director continues to headquarter in Rome, while **Wallace W. March,** managing director and co-owner, has established offices in London; **O. D. Blankenship,** vice president, operations, has transferred from Rome to The Hague, Holland; **B. G. Frazier,** vice president, engineering, has transferred to Tripoli, Libya, also included in the move were drilling engineers **G. W. Huff** and **Mario Severini; H. R. Stephens** has transferred from Nigeria to Libya; **O. J. Johnson** has been promoted to manager of operations in Nigeria; **W. H. Dowling** has joined IDC in Rome, and **J. N. Nixon,** formerly in charge of IDC's London office, has resigned.

what's Happening

among INDUSTRY ASSOCIATIONS



NOMAD Guests Outflank Football Coach

Football and food were main items of interest at a recent meeting of the Houston Chapter of NOMADS. Hal Lahar, University of Houston grid coach (fourth from left), was among the honored guests. Foreign guests flanking Lahar are (left to right): W. C. Lawson, Trans-World Drilling Company, Buenos Aires; Hisayoshi Sato, Arabian Oil Company, Ltd., Tokyo; G. Daily, SPAEF, Paris; Lahar and J. S. Wirtensohn and Dick Engelbrecht, Asiatic Petroleum Corporation.

W. L. McClusky Elected New AAODC President for 1960

W. L. McClusky of Dallas was elected president for 1960 of the American Association of Oilwell Drilling Contractors at the nineteenth annual meeting in Oklahoma City, October 11-13. McClusky succeeds Joe Zeppa, Delta Drilling Company, Tyler, Texas.

W. L. McClusky

A partner in the Dallas firm of M. J. Delaney Company, McClusky at present is secretary-treasurer of the association.

Elected vice president for the Gulf Coast region was J. Greer Wilcox, president of the Circle Drilling Company, Lake Charles, La. George B. Kitchel, vice president of drilling contracts, Kerr-McGee Oil Industries, Inc., Houston, was elected vice president for Offshore. Other newly elected vice presidents are: Herbert Woolf, Tyler, national vice president; F. M. Stevenson, Denver, Cable Tools; R. C. Tucker, Midland, West Texas and New Mexico; Hugh M. Gallagher, Los Angeles; M. E. Peden, Casper, Wyo., Rocky Mountains; and R. J. Moran, Wichita Falls, North and Central Texas.

Re-elected as regional vice presidents were Don Slape, Olney, Ill., Michigan, Illinois, Indiana and Kentucky; J. L. Strauss, Tulsa, Central Mid-Continent; E. F. Fullen, Lafayette, wells servicing, and A. Earl White, Tyler, cretaceous and tertiary basins.

Warren L. Baker was re-elected executive vice president. Joseph M. Shelton, Dallas, was re-named general counsel.

Elected Gulf Coast regional director was Rex Parks. Eleven other Houstonians were named directors-at-large. They are C. W. Alcorn, Joe K. Butler, M. F. Clegg, Earl C. Hellums, John B. Holmes, George B. Kitchel, Morris McDannald, D. E. McMahon, C. B. Webster, Frank J. Whitley and R. J. Wolfe.

J. K. Maxwell, president of Carter-Jones Drilling Company, Inc., Kilgore, Texas, was presented the annual President's Award for his "outstanding leadership in the field of chapter activities." The presentation was made by AAODC President Joe Zeppa.

Eight men were presented Meritorious Service Awards by the AAODC for their outstanding contributions to the drilling industry. These men are Arthur Lubinski, Pan American Petroleum Corporation, Tulsa; Henry Woods, Hughes Tool Company, Houston; Stanley Moore, Drilco Oil Tools, Inc., Midland; C. J. (Red) Davidson, Davidson Drilling Company, Inc., Fort Worth; Earle C. Flesher, Johnson & Flesher Drilling Company, Oklahoma City; Will I. Lewis, Will I. Lewis Drilling Company, Mt. Vernon, Ill.; John Woodruff, Petroleum Extension Service, The University of Texas, Austin, and F. A. (Pug) York, Miller & York, Inc., Bakersfield, Calif.

Dr. R. C. Moore Made Member Of Kansas Geological Society

Dr. Raymond C. Moore, Kansas geologist who has received many honors from local, national, and international professional scientific groups, received another honor at the Mid-Continent Regional Meeting of the American Association of Petroleum Geologists in Wichita, October 29.

Dr. Moore principal geologist of the State Geological Survey of Kansas and Distinguished Professor at the University of Kansas, became an honorary member of the Kansas Geological Society. Elbie G. McNeil of Nadel and Gussman, Wichita, president of Kansas Geological Society (KGS), made the presentation at the meeting's opening session.

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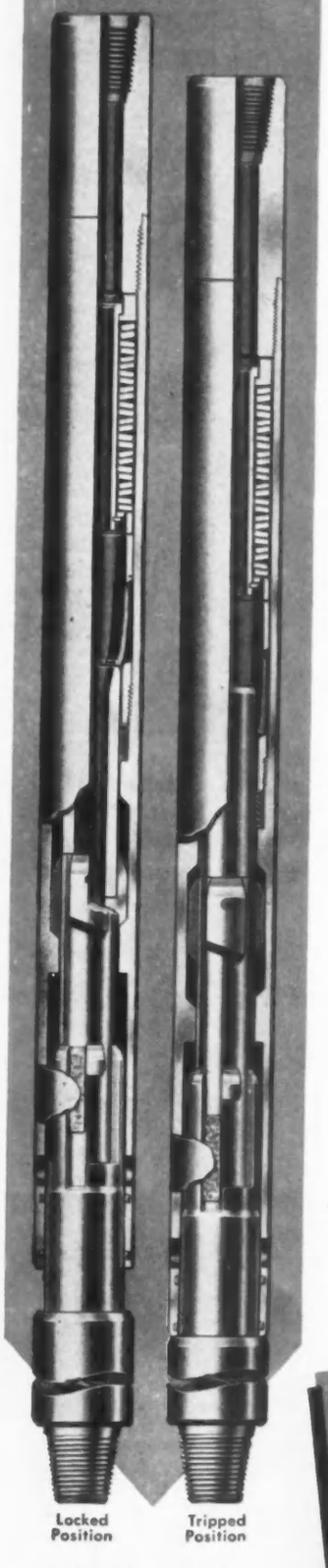
For running in the drill string . . .

Positive JAR-DOWN ACTION

. . . plus Safety Joint protection!

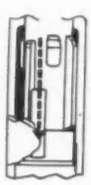


See the Shaffer section of your Composite Catalog.

THE SHAFFER-WAGGENER BUMPER SAFETY JOINT

There is no other tool like the Shaffer-Waggener Bumper Safety Joint. It combines—in ONE tool—a choice of *jar-down* and *releasing* actions, both under complete control of the operator. What's more, the tool is so rugged it is run as part of the drill string to protect against stuck pipe.

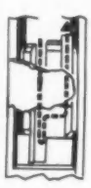
In actual well service it has operated easily at depths below 18,000 feet, and has given no operating problems even in directionally-drilled wells with extreme slant.



Jar-Down Action

RUN IT IN THE DRILL STRING—It is specifically designed to withstand the continuous vibration and heavy torque loads of today's drilling operations.

TO JAR DOWN whenever the drill pipe threatens to stick—or to drive drill collars out of keyseats and to free "balled-up" bits—simply slack off weight equivalent to about 2,000 feet of drill pipe onto the tool. This releases the tripping mechanism, automatically striking a sharp *down* blow. Raising the string automatically re-sets the tool for another blow—and blows can be struck repeatedly as fast as the string can be raised and lowered. And no torque or twisting strains are placed in string!



Releasing Action

TO RELEASE, in the event jarring will not loosen the stuck string, simply trip the tool and apply reverse torque as the string is slowly raised. Only one-sixth turn of the tool rotates the drive keys into unlocking slots so that complete release is effected by continuing to raise the string.

ANOTHER ADVANTAGE—the tool transmits full torque loads in *either* direction through three rugged drive keys—not through easily-damaged threads. It is the strongest joint in the string—not the weakest, as with conventional safety joints.

Also, the tool can be re-connected again by simply lowering the top portion over the lower portion and reversing the releasing action. It is ideal for use in fishing strings!

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36 years OF OIL TOOL LEADERSHIP

R. B. Brown

W. S. Hallanan

Russell B. Brown Honored At IPAA October Banquet

Russell B. Brown, general counsel of the Independent Petroleum Association of America, was honored in Tulsa at a banquet in recognition of his long service to the petroleum industry. The function took place October 26, highlighting IPAA's 30th anniversary meeting, October 25-27.

Principal speaker at the banquet was Walter S. Hallanan, chairman of the National Petroleum Council and president of Plymouth Oil Company. Brown has announced plans to retire at the end of this year, after 30 years of service.

Walker L. Cisler Elected New President of ASME

Walker L. Cisler, president of the Detroit Edison Company, has been elected president of The American Society of Mechanical Engineers.

Also, elected to head the 50,000-member organization were four vice presidents and three directors. The vice presidents are: Charles H. Coogan, Jr., head of the mechanical engineering department of the University of Connecticut; Donald E. Marlowe, dean of the school of engineering and architecture and professor of mechanical engineering at the Catholic University of America, Washington, D. C.; Henry N. Muller, Jr., vice president and chief engineer of Canadian Westinghouse Company, Ltd., Hamilton, Ont.; and William C. Heath, director of market development for Solar Aircraft Company, San Diego, Calif.

To serve as directors, members chose Everett M. Barber, senior research technologist of the research division, Texaco, Inc., Beacon, New York; William H. Larkin, New England manager for the Air Preheater Corporation; and Clarence C. Franck, Sr., consulting engineer, steam division, Westinghouse Electric Corporation, Lester, Pa.

The new officers will begin their duties at the business meeting on November 30 at ASME's Annual Meeting in Atlantic City. Cisler will serve for a one year term, the vice presidents for two and the directors for four years.

Two Local Sections in Canada Receive Charters from SEG

Local sections of the Society of Exploration Geophysicists have been chartered in Edmonton, Alta., and Regina, Sask., it has been announced by E. V. McCollum, SEG president.

President of the Geophysical Society of Edmonton is A. Sheldon Gibson, of Imperial Oil Limited, and A. C. Armstrong, of British-American Oil Company, Limited, is president of the Regina Geophysical Society.

McCollum also announced that a petition has been received from the Cochabamba, Bolivia, society and in Corpus Christi, Texas, plans for the 19th United States section are under way.

WHO'S MEETING WHERE

Nov. 4– 6	Rocky Mountain Oil and Gas Association, 14th Annual Convention, Cosmopolitan Hotel, Denver
5– 6	AAPG, Pacific Section Regional Convention, Ambassador Hotel, Los Angeles.
9–11	API, 39th Annual Meeting, Conrad Hilton, Palmer House and Congress Hotel, Chicago
9–12	SEG, International Meeting, Biltmore Hotel, Los Angeles.
10–11	API, Board of Directors Meeting Conrad Hilton Hotel, Chicago.
11	API, Executive Committee of Board of Directors, Conrad Hilton Hotel, Chicago.
11–13	Gulf Coast Association of Geological Societies, Executive Committee, Coliseum, Houston.
13–14	"Tulane Program on Minerals and Tidelands Law," Tulane School of Law, Tulane University, New Orleans.
19	AIME, Joint One-Day Conference, Great Bend Section, Wichita, Kan.
19	West Texas Oil & Gas Association, Twenty-sixth Annual Meeting, Hotel Windsor, Abilene, Texas.
Dec. 3– 5	Interstate Oil Compact Commission, Sheraton Hotel, Philadelphia.
7	AIME, Arizona Section, Annual Meeting, Tucson, Ariz.
20	Oil Trades Association of New York Meeting, Waldorf-Astoria Hotel, New York City.
Jan. 11–13	First International Symposium on Arctic Geology, Jubilee Auditorium, Calgary, Alberta.
Feb. 14–18	AIME, Annual Meeting, Statler Hotel, New York City.
Mar. 14–18	NACE, 16th Annual Meeting, Memorial Auditorium, Dallas.
16–18	API, Division of Production, Southern District Meeting, Hilton Hotel, San Antonio, Texas.
23	Oil Trade Association of New York Meeting, Waldorf-Astoria Hotel, New York City.
30 thru Apr. 1	API, Division of Production, Mid-Continent District Meeting, Broadview Hotel, Wichita, Kan.
April 20–22	API, Division of Production, Rocky Mountain District Meeting, Gladstone, Henning and Townsend hotels, Casper, Wyo.
20–22	NPA, Semi-annual Meeting, Hotel Cleveland, Cleveland.
24–26	IPA of America, Mid-Year Meeting, Denver-Hilton Hotel, Denver.
25–28	AAPG-SEPM, Annual Meeting, Chalfonte-Haddon Hall, Atlantic City, N.J.

Nomads' Chapter monthly meeting: Los Angeles, second Wednesday, Jonathan Club, Wallace A. Sawdon, Secretary. Houston, second Monday, Ye Old College Inn, Harry E. Estes, Secretary. Dallas-Fort Worth, first Monday, Greater Dallas Club, Hank Davis, Secretary. Tulsa, Hotel Tulsa, Gilbert Swift, Secretary. New York, first Monday, Hotel Biltmore, Jesse E. Hickman, Secretary.

For fishing, testing and core-drilling strings . . .

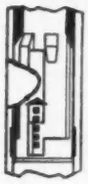
. . . plus Safety Joint protection!

Positive JAR-UP ACTION

THE SHAFFER OIL-SEALED JAR SAFETY JOINT

The Shaffer Oil-Sealed Jar Safety Joint is the only tool that combines a choice of *jar-up* and *releasing* actions, both under complete control of the operator at all times. What's more, all operating parts are sealed in a chamber filled with clean oil, fully protected against mud, sand and corrosive fluids.

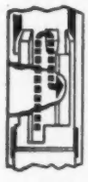
The sealed-in-oil protection not only safeguards against abrasion and corrosion, and minimizes pressure differentials on packing elements, but also insures constant operating characteristics at all depths. This makes the tool ideal for fishing, testing and similar strings where light connections and equipment are used!



Jar-Up Action

JARRING ACTION IS AUTOMATIC—simply raise the drill string until tension equals the pre-set tripping load, whereupon a sharp up blow is struck. Lowering the tool automatically re-sets the tripping mechanism for another blow—and repeated blows can be struck as fast as the string can be raised and lowered.

ONLY STRAIGHT PULL is necessary to operate the tool—no torque or other secondary operations to affect the light connections commonly used in fishing, testing and coring strings.



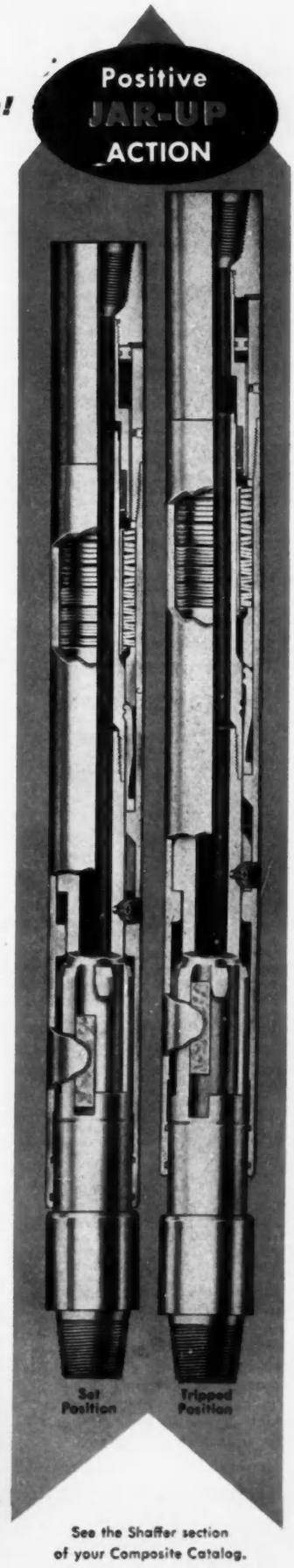
Releasing Action

TO RELEASE, in the event the fish or stuck string cannot be loosened, simply trip the tool and apply reverse torque as the string is slowly lowered. Only one-sixth turn of the drive keys rotates them into an unlocking slot whereupon raising the string allows the parts to unlock.

AND NOTE THIS—not only does the tool transmit full torque loads in *either* direction, but no threads are used in the releasing mechanism. Therefore there's no risk of torque over-tightening the tool—nor can reverse rotation accidentally release it.

Also, force of the blow is absorbed by integral knocker heads—not by easily damaged drive keys or threads. The tool is designed for *sustained* jarring operations. And since it does not depend upon friction for its tripping action, the Jar Safety Joint always operates with the same pre-set action. Light strings are not subjected to unpredictable loads!

Free 8 page booklet gives many other facts about the Shaffer Oil-Sealed Jar Safety Joint. Write for it—or ask your nearest Shaffer representative.



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For more data on advertised products, use Readers' Service Cards, last page.

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Flex-Seal

DOWN-HOLE PUMP PLUNGERS

Now with NYLON rings for 1-1/4, 1-1/2, 1-3/4 and 2" insert pumps and 1-25/32" common working barrels.

- INCREASE PRODUCTION
- REDUCE SANDING-UP
- INCREASE LIFE OF BARRELS
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- REDUCE STOCK (Valve Cups) to ½ Your Former Stock
- REDUCE COSTS

Flex-Seal ring is actually two-rings-in-one. They have been separated here to show split construction as a mated pair.

Assembled Flex-Seal ring shows patented, offset bevels which permit flushing of gas and sand during the free stroke of the plunger or barrel.

Because of their unique construction, Flex-Seal rings expand to the bore of the barrel during pumping stroke for maximum production efficiency. Damaging metal-to-metal contact is eliminated. *Write for literature and prices.*

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What's Happening among SERVICE and SUPPLY MEN

Fred W. Ayres

M. E. Montrose

Howard Hughes, president and chairman of the Board of **Hughes Tool Company,** has announced the appointment of **Fred W. Ayres** to the newly created office of vice chairman and the appointment of **Maynard E. Montrose** as senior vice president and general manager. Both appointees reside and make their offices in Houston, headquarters of the company. Ayres has retired from the position which he held for 14 years now to be occupied by Montrose, Hughes disclosed. Both men have been directors of the company for many years and Montrose has for 11 years served as vice president in charge of sales.

W. H. Siems

Montrose announced in Houston that **W. H. Siems,** general sales manager, has been promoted to the vacated post of vice president in charge of sales.

Ayres joined Hughes Tool Company in 1943 after serving in World War II as an executive in the aircraft division, manufacturing section, of the War Production Board. Previously he had gained wide recognition as a manufacturing executive and consultant both in England (with Daimler Motor Car Company) and, earlier, in the United States with DuPont, General Motors and others. He holds a number of directorships, including one with Trans World Airlines, a Hughes Tool Company subsidiary.

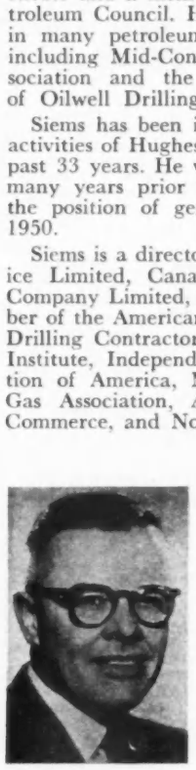
Montrose is a director of the Bank of Texas. He is also a director of Trans World Airlines and Hugh B. Williams Company, the latter a manufacturer of mining machinery. He was for several years on the board of Welex Jet Services, Inc.

Montrose, who joined the executive staff of Hughes Tool Company in 1947, has been identified with the oil industry throughout his business career. He started as petroleum specialist for General Electric Company in Dallas and Houston in 1925. He left that company to join Lane-Wells Company in Tulsa, serving as vice president and director until 1945 when he resigned to become president and general manager of Marion Power Shovel Company with whom he remained until joining Hughes.

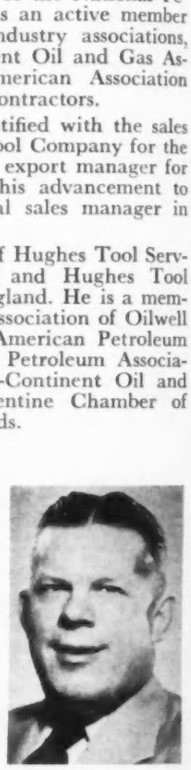
Montrose is a director and past president of the Petroleum Equipment Suppliers Association. He was a director for four years of the American Petroleum Institute and a member of the National Petroleum Council. He is an active member in many petroleum industry associations, including Mid-Continent Oil and Gas Association and the American Association of Oilwell Drilling Contractors.

Siems has been identified with the sales activities of Hughes Tool Company for the past 33 years. He was export manager for many years prior to his advancement to the position of general sales manager in 1950.

Siems is a director of Hughes Tool Service Limited, Canada, and Hughes Tool Company Limited, England. He is a member of the American Association of Oilwell Drilling Contractors, American Petroleum Institute, Independent Petroleum Association of America, Mid-Continent Oil and Gas Association, Argentine Chamber of Commerce, and Nomads.



C. W. Beauchamp



K. M. Hickman

Link-Belt Company has announced that **Charles W. Beauchamp** has been appointed marketing manager and will head up all sales activities of the firm's Ewart plant in Indianapolis, Ind. At the same time **Kendrick M. Hickman** was appointed sales manager. Beauchamp replaces the retiring **Forest H. Spencer.**

D. B. Winfrey

Donald B. Winfrey has been appointed assistant to the president for **Petty Geophysical Engineering Company.** A specialist with 25 years in the petroleum industry, Winfrey will be responsible for geophysical operations of the company and will operate from the main office in San Antonio, Texas.

Peck Meier

Blaine Johnston

Peck Meier, formerly manager of sales for the southern division of **Engineered Oil Tools, Inc.,** has been named general manager for the firm. **Blaine Johnston,** formerly general manager, has assumed new duties as vice president.

W. H. (Buddy) Armstrong has been appointed company regional sales manager for Oklahoma, Kansas and North Texas; and **T. H. Patterson** as division manager with headquarters in Oklahoma City for **Reed Roller Bit Company.** Also, it was further announced that **G. M. (Choc) Charleston** has been named Reed Special Salesman in Oklahoma City.

Calvin D. Sholtess has been named division sales manager for **Hughes Tool Company** with headquarters in Bakersfield, Calif. At the same time, **Thomas E. Dobbins** was promoted to regional sales coordinator at Denver; **Leonard G. Parrott** promoted to regional sales coordinator at Dallas; **M. Gordon Clarke** to regional special sales representative at Dallas; and **Dean L. Leyerly** and **Floyd E. Van Hook,** division special representatives at Farmington, N. M., and Oklahoma City, respectively.

Philip L. Robbins

Baash-Ross Division of **Joy Manufacturing Co.,** has announced the appointment of **Philip L. Robbins** as district sales representative in Natchez, Miss. Prior to joining Baash-Ross, Robbins was district manager for the Lane-Wells Company in Natchez.

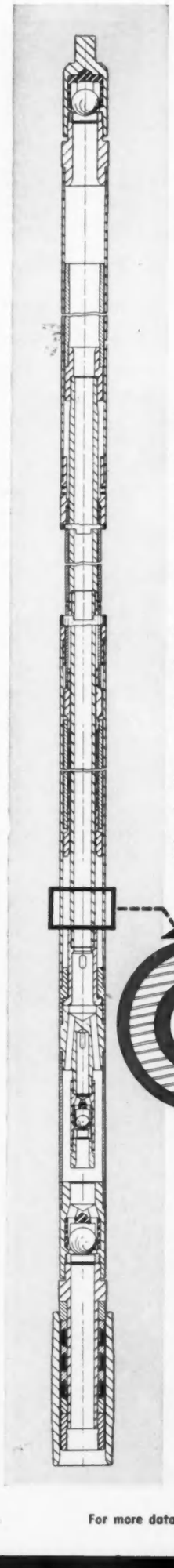
C. N. (Nick) Vance has been appointed sales representative for **Gustin-Bacon Manufacturing Co.** in the West Texas, New Mexico and Four Corners area.

Herb J. Hawthorne, Inc., has named **John W. Borror** field sales manager in Houston.

Rockwell Manufacturing Company's Petroleum and Industrial Meter Division has appointed **Nelson E. Davenport,** export sales manager, Meter and Valve Products.

Marshall S. Lutz has been named **Kobe, Inc.'s** Eastern sales representative. Lutz will headquarter in Detroit.

Gulf Coast Machine & Supply Company has announced the transfer of **Jerry Focher** from the Corpus Christi District to Wichita Falls, Texas. Forcher will represent Gulfco in the north central Texas District with division headquarters in Dallas.



Get More Production with

PACIFIC'S DOUBLE BARREL

Insert Rod Plunger Pump

This particular design of Pacific's Type "D" Insert Rod Pump is one of the many tried, and is the direct result of engineering proved by actual field tests and operation. Over a period of years this pump was developed so that it could be removed on the rods for servicing ... yet produce at capacities equal to or greater than a Tubing Liner Pump. Many problems were encountered, but for each a satisfactory solution was found. The result is a most efficient and trouble free insert rod pump for handling large capacities.

The Type "D" Insert Rod Pump consists basically of two R. W. pumps in tandem. The upper pump is a Traveling Barrel Pump. The lower pump is a Traveling Plunger Pump.

WRITE FOR BULLETIN 204

Vertical cross sectional view of lower pump displacement chamber showing area which is between Inner Plunger Tube and Precision Tube. This area represents approximately 60% of the upper pump. Both pumps load on the up stroke and discharge on the down stroke.

PACIFIC PUMPS

Inc... A Division of Dresser Industries, Inc.

HUNTINGTON PARK, CALIFORNIA

Mid-Continent :
1358 So. Sheridan Ave., Tulsa 12, Oklahoma
Pacific Pumps of Canada, Ltd.,
Edmonton, Alberta

ONE OF THE DRESSER INDUSTRIES

PACIFIC®

DW-19

For more data on advertised products, use Readers' Service Cards, last page.

Ray H. Fara has been appointed eastern sales manager for the **Instrumentation Product Group** of the **Texas Instruments Incorporated Geo Sciences and Instrumentation Division, Texas Instruments, Inc.**

Sperry-Sun Well Surveying Company has named **Harry M. Lowe** division manager and will supervise the activities of Sperry-Sun's new Western Division, which consists of Long Beach, Ventura and Bakersfield, Calif.; Casper, Wyo.; and Denver. Lowe will continue to maintain his office in Long Beach.

George C. Jennings has been named Wire Rope Sales manager of **The Colorado Fuel and Iron Corporation.** Jennings was formerly the company's New York District sales manager.

Burton Aulick

Travis Phillips

Halliburton Oil Well Cementing Company has announced three major administrative changes in its field operations. **Travis Phillips,** who has been division manager at New Orleans replaces the retiring **J. L. McBride** as division manager at Shreveport. **Burton Aulick** has been promoted from assistant manager to manager at New Orleans.

Robert W. Blake has been elected vice president, sales, **Shand and Jurs Company.** Blake succeeds **E. E. Jurs** who has retired.

The Petroleum Equipment Suppliers Association has announced the addition of two new members. These are **Fort Worth Pipe & Supply Company,** Fort Worth, and **The Servco Company,** Long Beach, Calif.

U.S. Steel's Oil Well Supply Division has announced the following promotions. **Joe Charles Bradley** as field representative at Corpus Christi, Texas; **Melvin M. Brunet** as field representative at Eunice, La.; **William H. Harris** as field representative at Laurel, Miss.; **Roy A. Johnston** as representative for the firm at El Dorado, Ark.; **Robert Paul Kitto** as city representative at Wichita Falls, Texas; and **Donald Harold Schoonover** as city representative at El Paso, Texas.

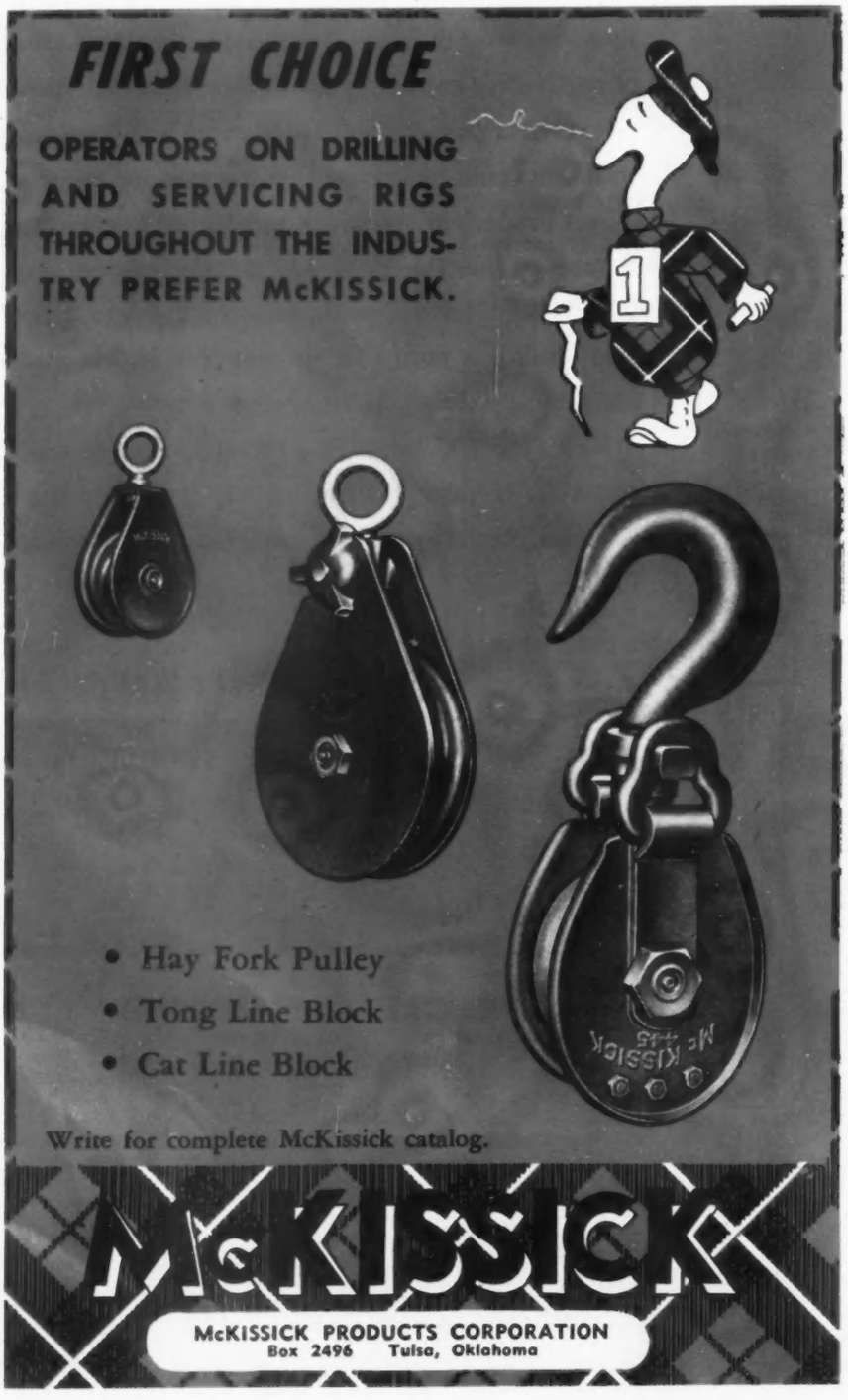
J. F. Allen has been promoted to manager of manufacturing of the Pressure Control Equipment Division for **Cameron Iron Works, Inc. Harry H. Walsh** has been chosen to succeed Allen as missile plant manager.

D. H. Keith

Donald H. Keith recently joined the technical staff of **Rig Time, Inc.** He has been appointed to the post of technical representative and engineer. As a consulting geologist, Keith has been active in the oil industry of the Ark-La-Tex area since 1954.

Schlumberger Well Surveying Corporation has made the following changes within that organization. **George C. Hepburn, Jr.,** has been named Northeast Division manager; **Milton E. Loy** has been appointed manager of the firm's Southeast area, headquartering at New Orleans; **Frank H. Yeagers** has been promoted to manager of the Mid-Continent area with offices at Tulsa; **William J. Bowen** has been named manager of the Louisiana Gulf Coast Division at Lafayette.

C-B Southern, Inc., Cooper-Bessemer Corporation subsidiary, has announced the following engineering staff additions to its Houston facility. **Harry L. Jackson,** former technical service manager and assistant chief engineer at the Union Tank Division of Butler Manufacturing Company, joins CB/S as a development engineer. **Richard L. Flowers** and **George H. Haltom** are new members of the CB/S Sales Engineering staff. Flowers was formerly division equipment engineer of the Phillips Petroleum Company, and Haltom was manager of machinery sales for the Houston Oilfield Material Company.


FIRST CHOICE
OPERATORS ON DRILLING AND SERVICING RIGS THROUGHOUT THE INDUSTRY PREFER McKISSICK.
• Hay Fork Pulley
• Tong Line Block
• Cat Line Block
Write for complete McKissick catalog.
McKISSICK
McKISSICK PRODUCTS CORPORATION
Box 2496 Tulsa, Oklahoma

DESIGNED TO ELIMINATE HIGH LIFTING COSTS ON SMALL VOLUME SANDY WELLS

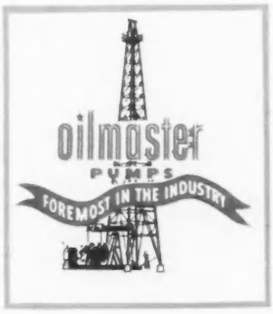
oilmaster

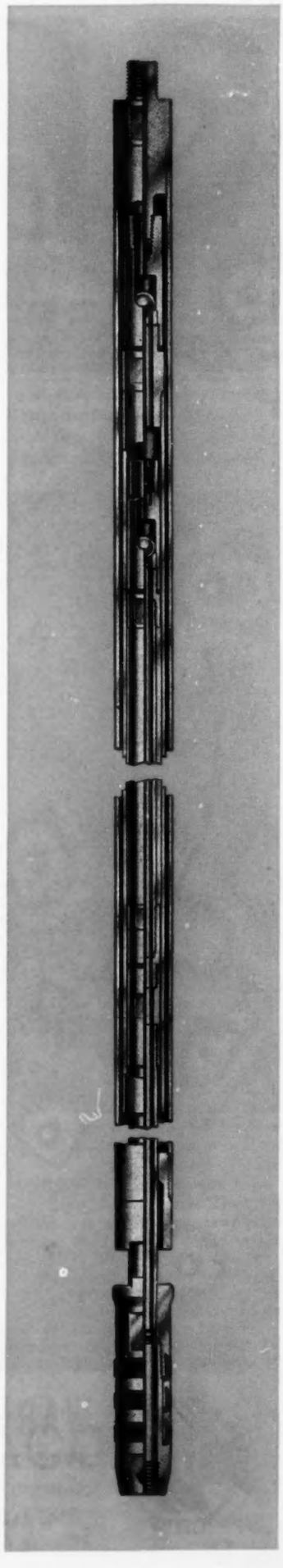
SAND HOG PUMPS

were designed with the elimination of high lifting costs as an objective — the results — a small bore pump so trouble free in its operation that it has actually prolonged the economic life of stripper wells.

The Sand Hog is purposely built with small fluid passages so the velocity of the discharged fluid remains high, preventing any settling of entrained sand. A skirt diverts the discharge of the fluid to a point below the bottom of the traveling barrel—continuously washing the hold-down and flushing the annulus between the pump and the tubing free of sand. The cleanest oil that will separate out of this produced fluid floats up between the pull tube and barrel, and on each suction stroke supplies a film of oil to lubricate and reduce friction between the barrel and plunger.

Ask your Oilmaster Representative to deliver a Sand Hog before your next pulling job and compare its trouble-free performance with that of any pump you have previously run.





FLUID PACKED PUMP CO.
Main Office and Plant, Los Nietos, California
DIVISION OF THE NATIONAL SUPPLY COMPANY
Distributed by the National Supply Co., Pittsburgh, Pa.
Export: The National Supply Co., Export Division,
600 Fifth Avenue, New York
Co-Distributors: Union Supply Company,
Beacon Supply Co., Industrial Supply Co.

Leland Auer

Don Etter

Grant Oil Tool Company has announced the appointment of **Don Etter** as sales manager and **Leland Auer** as chief engineer. Auer succeeds **Clarence Leathers** who has been promoted to executive engineer of Grant and its MacClatchie and Cosasco divisions.

Morris L. Bradford, Tulsa attorney and a partner in the firm of Bradford, Watson and Morley, has been elected to the office of executive vice president of the **Hoil Company,** Tulsa.

Mason-Neilan, Division of Worthington Corporation, has announced the appointment of **James M. McAlear** as sales manager.

Bethlehem Steel Company has announced that **Lee Fagg** has been promoted to assistant manager of sales; and **L. C. Graves** has been promoted to sales manager-Subsurface Production Equipment. Both men will be located in Tulsa and will be under the direction of **J. V. Spalding,** general manager of sales.

Jerry F. Boutwell

Jerry F. Boutwell has been appointed sales manager of the Oilwell Pump Section of **Byron Jackson Tools, Inc.** Boutwell, who has 12 years of experience in submersible pump sales, will headquarter in Byron Jackson's Tulsa plant.

B. T. Collins, salesman at Laurel, Miss., has been appointed store manager there for **Jones & Laughlin Supply Division.** Other appointments recently announced include **J. J. Hoffman,** former salesman at Lake Charles, La., has been appointed store manager there; **R. O. Dulaney,** salesman at Worland, Wyo., assigned as store manager at Worland; and **S. L. Easley,** saleman at Best, Texas, appointed store manager there.

James J. Gibbons has been appointed director of marketing for **A. O. Smith International, S.A.** Headquartering in Milwaukee, Wis., Gibbons will coordinate and develop the sales activity of the company throughout its world markets. Also, **Sidney McNiece** has been transferred to the Milwaukee administrative office to serve as assistant to the president. **C. W. Jewson** transferred to Caracas, Venezuela, as resident manager. **L. J. McConnel** transferred to Milwaukee to replace Jewson as product manager.

J. B. McDonough

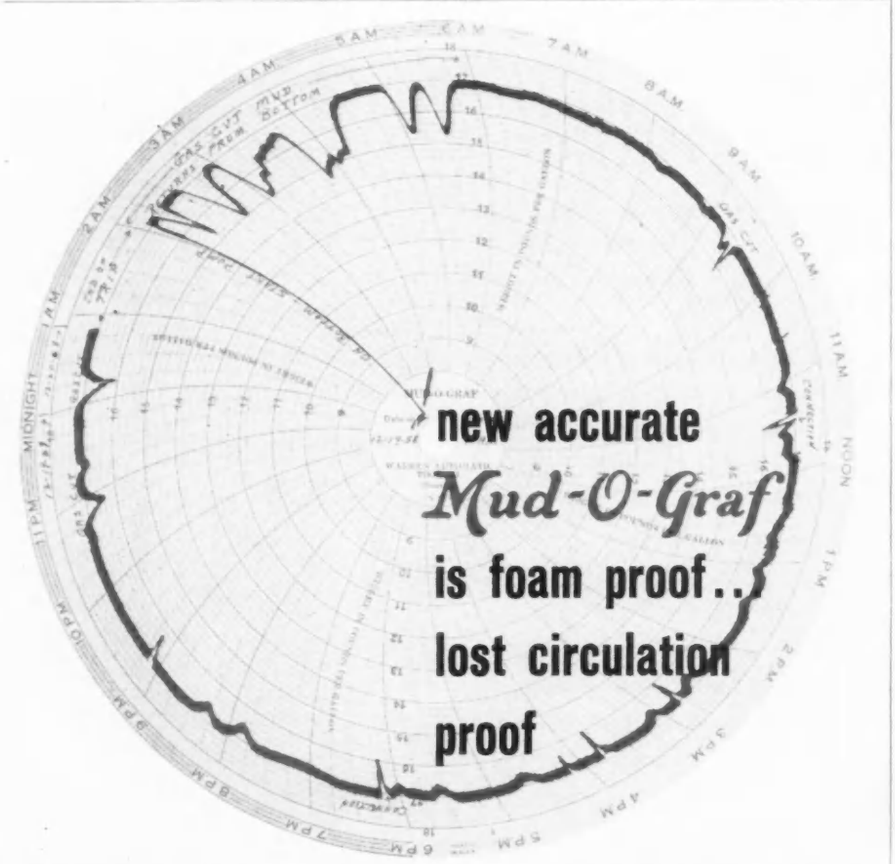
James B. McDonough has been appointed equipment sales representative for **Cardwell Manufacturing Company** in the Gulf Coast area. Prior to joining Cardwell, McDonough spent two years with United Supply in West Texas and 10 years with Continental-Emsco.

Well Surveys, Dresser Industries, has appointed **Dr. Howard Oshry** technical director. Oshry will be in charge of the company's research, testing and prototype manufacturing facilities and personnel.

W. L. Reynolds has been appointed sales manager of the Domestic Pressure Control Equipment Division, and **R. F. Farmer** and **I. M. Baker** have been promoted to Domestic-International Executive sales assistants, for **Cameron Iron Works, Inc.**

W-K-M, Division of ACF Industries, Inc., has announced the appointment of **Robert O. Wynn** as vice president of Engineering and Research, and **Henry C. Tooley** as vice president of Manufacturing.

William E. Scarborough has been named to a newly created position of Domestic sales manager by the **Reed Roller Bit Company.**



More than 1 million tons of mud have been weighed by Mud-O-Graf. This experience has led to the new, foam-proof, lost circulation-proof model.

A complete cycle of weighing is made every 45 seconds. The weighed sample is completely flushed out and passes over the shaker before the next fresh sample is taken.

The recorder can now be installed on the derrick floor without adverse effects from rig vibration on either its remarkable accuracy or its general operation:

Twenty years of experience in the mud weighing business has proved that there is no substitute for a completely accurate, continuous chart record of mud weight *placed in front of the driller.* Check these features:

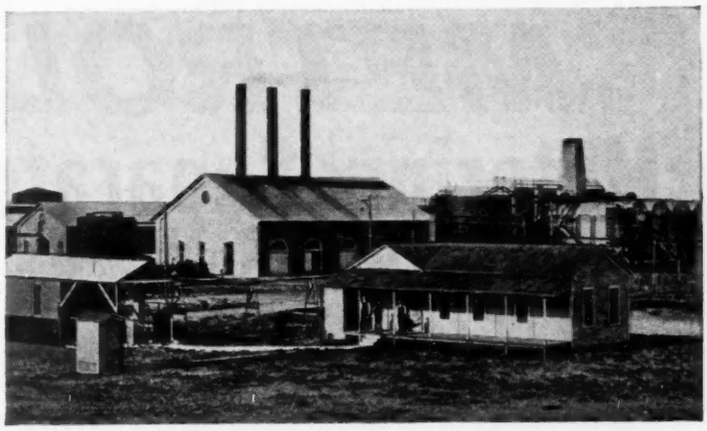
- A weighing unit that will handle lost circulation material or foamy mud.
- The sample is taken every 45 seconds directly from the mud stream and is not dependent on pumping to a remote location.
- Each sample is completely flushed.
- The weighing unit is smaller and easier to maintain.
- Continuous recording on a circular chart, where a full twenty-four hours is visible to the driller.
- Recording is easily readable and accurate to 1/2 of 1/10 pound per gallon.

WARREN AUTOMATIC TOOL CO.
3915 THARP STREET • HOUSTON, TEXAS
Phone CApitol 4-2511

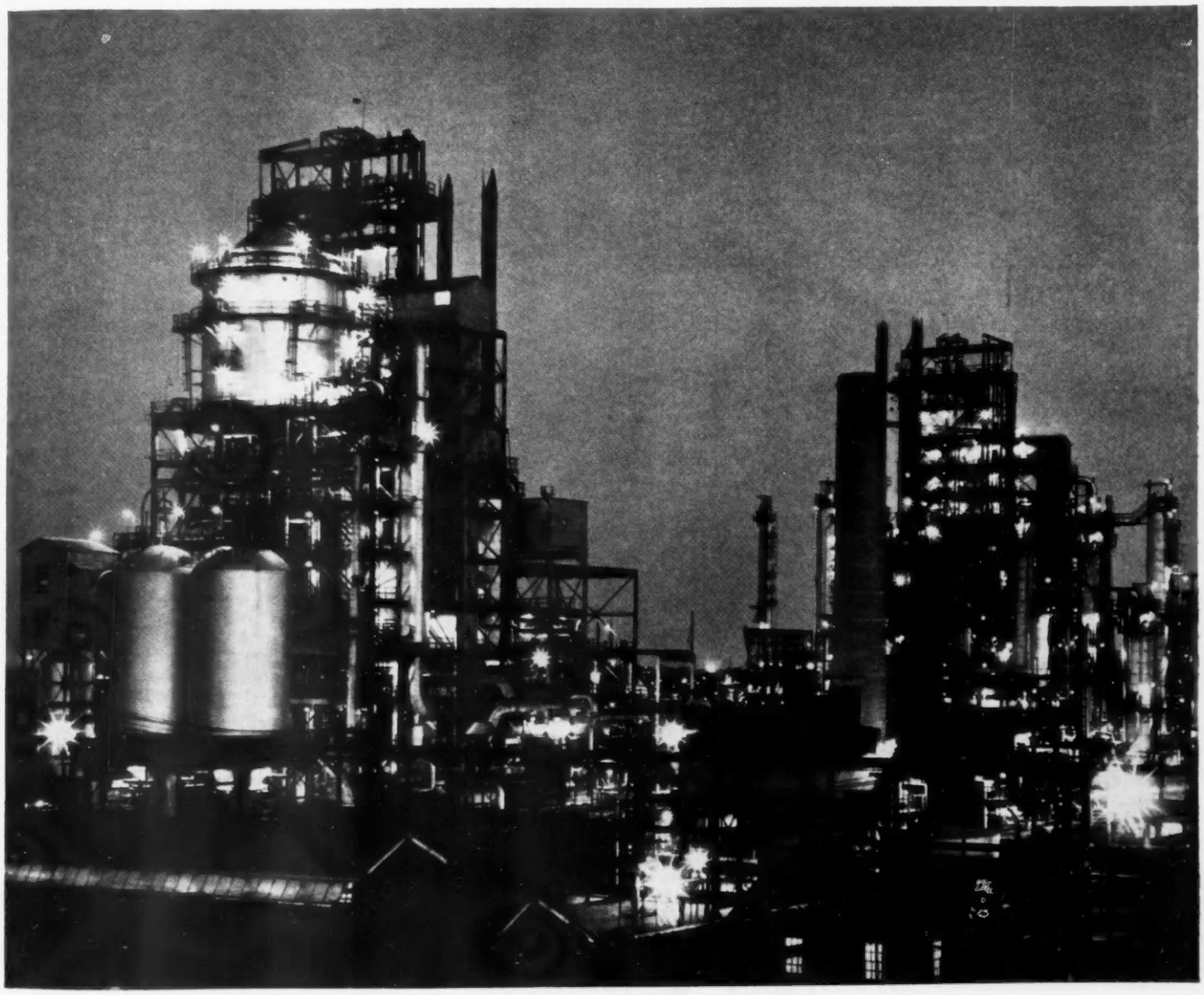
Lake Charles HEmlock 6-2265 | New Iberia EMerson 9-9862 | Harvey FOrest 6-1441

NEWS ON TEXACO PROGRESS

Two views of progress . . . 57 years apart



YESTERDAY. Texaco's first refinery at Port Arthur came into being in 1902 to turn the black crude oil — newly discovered in quantity — into useful products for mankind. Produced in simple stills, the first products were kerosine, naphtha, asphalt and primitive lubricants.



TODAY. At Port Arthur, and at 11 other major Texaco refineries in the United States, ultra-modern chemical wizardry uses many methods to produce constantly improved gasolines, perfected lubricants, and a myriad of other petroleum products. Because these products are so vastly improved, you can drive a more powerful car — jet planes can fly faster and farther — industry can operate more efficiently. And because it has constantly planned ahead, Texaco's growth has been continuous.

TEXACO

. . . CONSTANT PROGRESS IN OIL'S FIRST CENTURY

METROL®
Metering Separators
Do Double Duty
1 SEPARATE WELL FLUIDS
2 METER THEM

METROL SAVES YOU MONEY!

Rugged and accurate (99.9%), this double duty equipment will streamline your production layout.

It eliminates (1) the need for standard separators (2) manual tank gauging and (3) the cost of individual storage tanks.

You meter while you separate and record the flow from each well . . . then use a *common* storage tank.

Model 24MS—0109C Type C Metering Separator

ALL THIS . . . AND 99.9% ACCURACY, TOO!

The accuracy of Metrol METERING SEPARATORS in the field is a proven fact. That's why they are accepted by most regulatory bodies. You'll find these units are ideally suited for metering oil for royalty and tax payments, for testing wells, for segregating produced oil and for automatic lease operation.

EXCLUSIVE PATENT (Pat. No. 2,818,738)

Long time dependability in operation . . . plus economy . . . is assured by these two design features (1) A patented Snap Acting Liquid Level Controller that's exclusive with Metrol and (2) positive valving sequence that absolutely prevents the slippage of unmetered liquid.

WRITE OR CALL US TODAY for technical information. Get proof of the savings possible with Metrol METERING SEPARATORS. Let us know your problems and we'll develop a specific recommendation for you **that's Metrol engineered to save you money.**

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A METROL UNIT

to Meet Every Requirement

- DUMP VOLUMES ¼ bbl. to 30 bbls.
- WORKING PRESSURES 125 to 2400 psi

OIL METERING and Processing EQUIPMENT CORP.

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HOUSTON 18, TEXAS

Schlumberger Well Surveying Corporation has announced the promotion of a new location manager and reassignment of four engineers. **J. D. Cummingham,** formerly sales engineer at Venice, La., has been promoted to location manager at Donaldsonville, La. **L. S. Kersey,** formerly field engineer, Lake Charles, La., has been promoted to sales engineer at Lafayette; **J. E. Davis** is now sales engineer at Venice; **O. T. Maxwell** is now serving as sales engineer at Kermit, Texas; **R. H. Neustaedter** has been named sales engineer at Tyler, Texas.

D. W. Patrick

G. E. Lourie

Pittsburgh Pipe and Coupling Co., has appointed **Dale W. Patrick** sales manager. **George E. Lourie** has been made interplant administrator, responsible for coordinating activities of the main plant, the Anvil Products subsidiary, and affiliate, Canadian Coupling and Fittings, Ltd., Simcoe, Ont.

The branch of the **Wakefield Group of Companies** in New Zealand, which previously operated under the jurisdiction of the Group's Australian organization, has now assumed full Branch status with direct responsibilities to headquarters in London. General Manager of the branch is **R. F. Smillie.**

Bob L. Smiley has been appointed sales engineer for the Northern Division of **Engineered Oil Tools, Inc.** Smiley will represent the company in North Texas, the Panhandle, Oklahoma, Kansas and Canada.

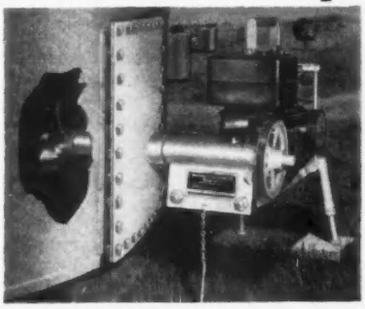
Continental-Emsco Company has appointed **W. D. Crowell** to the position of assistant treasurer. Crowell joined Continental-Emsco in 1948 and has served as division credit manager and assistant credit manager as well as in other capacities. He will office in the company's new world headquarters building in Dallas.

W. D. Crowell

Controls Division of Black, Sivalls & Bryson, Inc., has announced the appointment of **Jack Kohl** as manager of the Western Sales Region. Kohl will headquarter in Los Angeles.

U. S. Industries, Inc., has announced that **R. D. O'Brien** has been advanced to the post of group executive for the two petroleum equipment divisions of U. S. Industries, Inc.

Now you can get rid of all your BS* at a profit!



NEW Wichita-Smith Tank Agitator makes pipeline oil out of your tank bottoms and saves you money!

This new tank agitator blends **basic sediment* and chemicals quickly and thoroughly . . . settles water and results in up grading oil. The Wichita Propeller Unit is easily welded into position in lower half of manhole plate. One Wichita Power Unit can service any number of tanks. Often eliminates high priced heaters and treaters. Contact your local supply store or . . .

Write today for details!

WICHITA ENGINEERING CO.

3300 Arthur Street Wichita Falls, Texas

Clean PIPELINES
Reclaim TANK BOTTOMS
with **BrakeSol**®
an exclusive
PARAFFIN TREATING CHEMICAL

BRAKESOL holds paraffin in suspension! Inject it into gathering lines and BRAKESOL keeps them free of paraffin.

BRAKESOL reclaims tank bottoms without taking tanks out of service! BRAKESOL chemically dissolves paraffin and puts it back in solution into the oil. Cost is nominal compared to savings.

BRAKESOL is safe to handle and will not harm your equipment. Let BRAKESOL eliminate your paraffin problems NOW!

FOR SERVICE . . . Contact your Supply Store or nearby BrakeSol Treating Engineer.

BrakeSol INC.

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EXPORT DISTRIBUTOR: THE NATIONAL SUPPLY CO., EXPORT DIVISION

This Measure May Be O.K. for Fishermen

BUT Oil Gaging Needs Precision Equipment from W. H. Curtin & Co.

Complete stocks of Petroleum Gaging Equipment meeting all API and ASTM specifications are maintained for immediate delivery by W. H. Curtin & Co. Curtin oil testing centrifuges and tubes, thermometers and hydrometers, as well as all other gaging equipment, are of the finest quality and constructed for a long lifetime of use in field or laboratory. Replacement parts are readily available for all equipment. On your next order, specify the high quality gaging equipment you can rely on from W. H. Curtin & Co.

Write or call for your FREE copy of Curtin's 24-page illustrated catalog G-56 *Petroleum Gaging Equipment*.

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DOMESTIC EXPORT • CURTIN PETROLEUM TESTING EQUIPMENT

HOUSTON - DALLAS - NEW ORLEANS - JACKSONVILLE

Sales Offices: TULSA • BIRMINGHAM • CORPUS CHRISTI

Subsidiary: CURTIN DE MEXICO, S.A. de C.V., MEXICO CITY

Established 1922 U.S.A.

A. Rex Watkinson, Jr., has disposed of his interest in Crescent Oil Well Supply Company, which he served as president, to join **Lucey Products Corporation,** as special sales representative.

Richard A. Gentry, Gulf Coast Division manager for Continental-Emsco Co. since 1954, has purchased an interest in the **Gott Manufacturing Company,** and assumed duties with the firm.

American Iron & Machine Works Company has announced two promotions. **Haskell (Inky) Wotkyns** has been appointed division manager and will cover the East Texas, Texas Gulf Coast, Louisiana, California and Mexico areas. He will have offices in Houston. **Guy Tucker** has been appointed division manager for the Rocky Mountain and Canadian area. He will continue to headquarter in Denver.

J. S. Taylor

Wayne Lutke

James S. Taylor and **Wayne Lutke** have been named to new posts in the oil and gas equipment sales operations of **Graver Tank & Mfg. Co., a Division of Union Tank Car Company.** Taylor has become sales engineer for oil and gas equipment, operating in Tulsa. Lutke has been named district manager for sales of oil and gas equipment operating in Midland, Texas.

General Motors Electro-Motive Division has announced a series of organizational changes. **William H. Harvey** promoted to the newly created position of director of production. **B. B. Brownell** to the newly created post of director of research and engineering. **Thomas B. Dilworth** succeeds Brownell as chief engineer.

United Geophysical Corporation, Pasadena, Calif., has announced the transfer of **S. O. Patterson** to the Gulf Coast-Mid-Continent area including West Texeas as area manager replacing **J. D. Rookus,** president area manager in Houston. Rookus has been transferred to United Testing Laboratories in California.

Mid-Continent Supply Co. has announced the addition of three Delta Tank specialists to their West Texas and New Mexico Division. **George W. Williams** has joined Mid-Continent at Midland, Texas, as regional sales engineer; **James A. Kepley** has joined the company as division sales engineer in the West Texas and New Mexico Division; and **Ralph F. Kemp, Jr.,** is the new sales representative in Hobbs, N. M.

Franks Division, Cabot Shops, Inc., has announced a reorganization of its sales division. **Ken Lamer** has been appointed district manager of the West Texas New Mexico area. **Jeff Gray,** formerly at Farmington, N. M., will move to Odessa, Texas, and serve the Permian Basin. **Hillmar Heinritz** will continue as sales representative with headquarters in Odessa.

Kirk Usher has been appointed manager of Tubular Products Sales, for the **Aluminum Company of America.** He will headquarter in Pittsburgh and is responsible for the sale of extruded and drawn pipe and tubing.

L. Glenn Rader has been appointed vice president and special sales representative for **Maloney-Crawford** Tank and Manufacturing Company, for the New Orleans area.

General Electric has announced the addition of two specialists in the Marketing Research, Product and Sales Planning Component of the Marketing section in the company's Gas Turbine Department.

Charles R. Dygery has been named specialist-product planning, and **Kent L. Lewis** was named specialist-advertising and sales promotion.

Don Ahrens, has been appointed general sales manager of **Childers Manufacturing Co.,** Houston.

Walworth Company has announced the appointment of **Robert F. Snowden** as a sales representative in the company's Gulf Division.

Joe McGraw, Jr., has been appointed division manager for the Rocky Mountain area of **Security Engineering Division,** one of the Dresser Industries.

Aero Service Corporation has announced the election of **George Strawbridge** to its Board of Directors. **Virgil Kauffman** continues as Aero's president and operating head, while Strawbridge will be assistant to the president.

If you've a contract to drill for oil

CONSULT

REALL of ENGLAND

The finest name in the oil world for mobile camp equipment

REALL EXPERTS KNOW YOUR PROBLEMS

and will help you to solve them ECONOMICALLY and EFFICIENTLY

Reall Units are entirely all-metal. Their length ranges from 15′ to 35′ in multiples of 5′; their width is either 8′ or 10′. They are supplied skid-mounted; semi-trailer-mounted, with two or four wheels, or with four wheels close-coupled.

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Head Office & Works : 470-474 Bath Road, Cippenham, Slough, Bucks.
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Cablegrams : REALLEX LONDON
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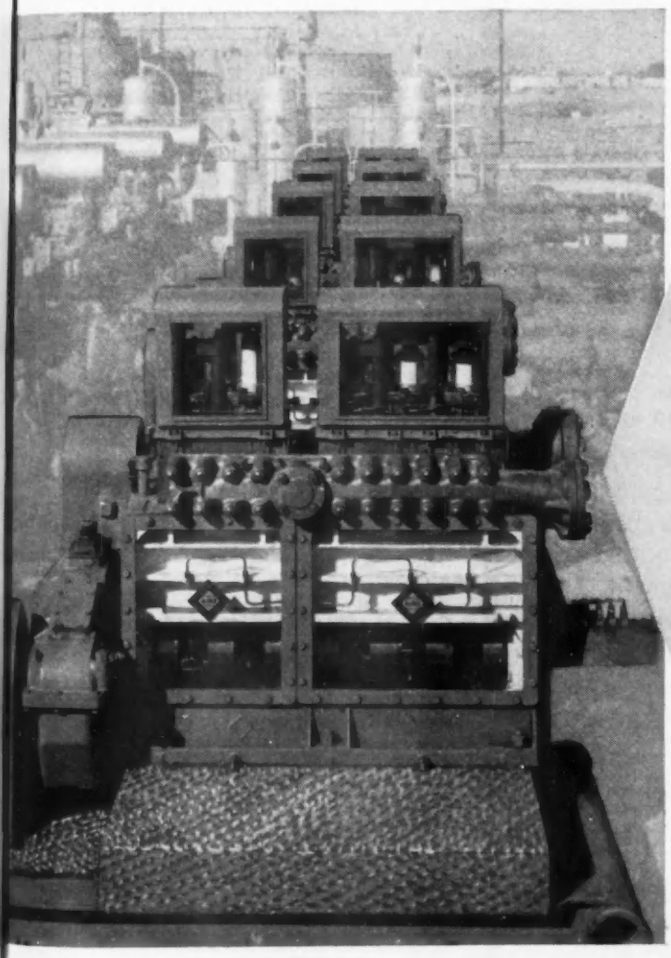
UNDER NORMAL CONDITIONS . . .

Any Good Pump will do the Waterflood Job



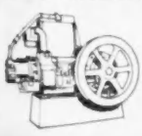
"Five Ajax Quintuplex pumps on Long Beach project."

. . . but Ajax builds in anticipation of troublesome suction conditions—water hammer—excessive loads—high stress, fatigue causing conditions . . .

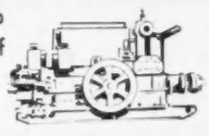
Thus an Ajax pump reduces down time and increases "ON THE LINE" pumping time.

- Streamlined discharge manifold — reduces turbulence
- Double row tapered permanently factory adjusted roller main bearings result in lowered maintenance cost.
- "Safety Link" Tie Rods — protect vital components during highly abnormal conditions

AJAX OIL FIELD PUMPS



AJAX also builders of



AJAX IRON WORKS CORRY, PENNSYLVANIA

OIL FIELD DISTRIBUTORS: The National Supply Co., Pittsburgh, Pa.

- Bethlehem Steel Company, Supply Division, Tulsa, Oklahoma

Security Engineering Division, Dresser Industries, has appointed **W. C. (Dub) Gray** as its Gulf Coast Division manager. Prior to his new appointment, Gray had been Security's Distributor Sales coordinator.

William L. Peterson has been appointed manager of the Philadelphia branch of **White Truck Division** of **The White Motor Company.**

Carra L. Lane has been appointed manager of plant operations for the **Chicago Pneumatic Tool Company.** All manufacturing and engineering operations in the company's domestic plants at Utica, N. Y., Franklin, Penn., and Fort Worth will be under his jurisdiction.

Ellis D. Verink, Jr., has been named manager of chemical and petroleum industry aluminum sales for **Aluminum Company of America.** He will move to company offices in Pittsburgh.

Ernest A. Sticha has been named chief research metallurgist by **Edward Valves, Inc.,** subsidiary of **Rockwell Manufacturing Company.**

The Colorado Fuel and Iron Corporation has appointed **Kingdon B. Dietz** as New York District sales manager.

Reed Roller Bit Company has announced the recent appointment of **A. J. Organ,** formerly of Maracaibo, Venzuela, as special representative in Bogota, Colombia.

B. H. Milner has been appointed store manager for **Jones & Laughlin Supply Division** at Alice, Texas. Milner had been employed as storeman at J&L's Luling, Texas, store.

U.S. Steel's Oil Well Supply Division has announced the appointment of **L. D. Kinman** as city representative in Houston. Kinman was located at Corpus Christi, Texas, prior to his present appointment.

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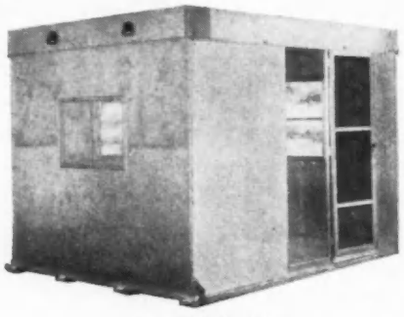
WORLD'S LIGHTEST-STRONGEST PORTABLE HOUSING UNITS



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$995.00*

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Weight: 798 lbs.

Shipping Size: 8' x 10' x 1'

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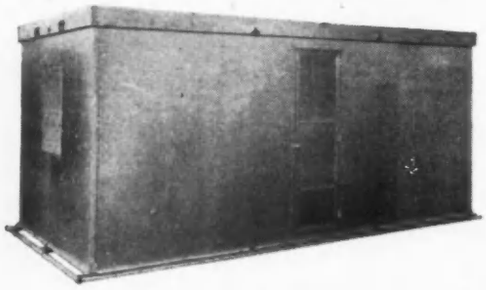

8' x 16' Model

$1595.00*

Weight: 1010 lbs.

Shipping Size: 8' x 16' x 1'

SOLD THROUGH YOUR SUPPLY STORE

* Prices subject to change

$250,000 Expansion Program Launched By Oil Center Tool

Oil Center Tool Company has launched a quarter-million-dollar expansion program which includes a new research and development laboratory, added manufacturing areas, and new machine tools and an addition of engineering personnel.

The Houston plant expansion includes a 40-by-60-foot research and development laboratory, a 50-by-75-foot assembly and painting structure, in addition to smaller additions for metal plating and other purposes.

Already this year, O-C-T has purchased and installed a $60,000 turret lathe, an automatic vertical band saw and automatic painting equipment. On order is an automatic horizontal milling machine which will be used in the production of Unitrees, the new look in Christmas trees. For research and development purposes, the company has already added seven engineers this year.

Parkersburg Rig & Reel Co. Announce New Executive Offices

Establishment of the operating portion of the company's executive offices in Houston has been announced by The Parkersburg Rig & Reel Company. The new offices are located on Richmond Avenue.

Craig M. Rowley, executive vice president and general manager, spearheaded the move to Houston along with J. W. Robbins, vice president and general sales manager, and Fred King, manager of Manufacturing of Oil Country Products. Other departments of the company are under study for possible future relocation.

Cummins Engine Company Announces New Organization

A new service organization to strengthen Cummins Diesel service throughout the free world has been announced. A staff of service representatives has been named to provide technical training, support Cummins dealers and instruct owners and operators on the uses of servicing of Cummins Engines.

Under the new announced plan, new Cummins service representatives will be located in Mexico City, Mexico; Havana, Cuba; Sao Paulo, Brazil; Buenos Aires, Argentina; Zurich, Switzerland; Lisbon, Portugal; Johannesburg, South Africa; Beirut, Lebanon; Singapore, and Sidney, Australia.

Garrett Oil Tools Appoints Three New Sales Agents

Garrett Oil Tools, Division of U. S. Industries, Inc., has announced the appointment of three new agents to handle sales of Garrett equipment in parts of Europe, Africa and the Middle East.

Representative Forniture Petrolifere, R.F.P., Milan, Italy, will handle Garrett equipment in Italy and the Italian Islands, Libya and Egypt. Societe D'Etudes Petrolieres, France, is the new Garrett agent in France, French West Africa, Madagascar, Algeria, Morocco and Tunisia. Sales in Turkey, Kuwait, Iran, Persian Gulf and Saudi Arabia, will be handled by Ismail Tiner, Ankara, Turkey.

Baash-Ross to Distribute Derrick String-A-Lite

Baash-Ross Division of Joy Manufacturing Company has been named domestic distributor for Derrick-String-a-lite assemblies for masts and derricks. Manufacturing will continue to be done by the Electrical Products Division of Joy Manufacturing Company in St. Louis, Mo.

NEW BOOKS

IGNEOUS AND METAMORPHIC ROCKS OF PART OF SEQUOIA AND KINGS CANYON NATIONAL PARKS, CALIFORNIA, Department of National Resources, Division of Mines, State of California, San Francisco, Donald C. Ross, $75.

The area described in this report includes about 150 square miles on the west slope of the Sierra Nevada in Tulare County, Calif. Also included are maps, photos, tables and figures. As an added feature, there is a geologic map of California Alturas Sheet, $1.50.

•

APPLIED PETROLEUM RESERVOIR ENGINEERING, Prentice-Hall, Inc., New York, B. C. Craft and Murray F. Hawkins, Jr., $12.

This up-to-date and seemingly authoritative book makes a significant contribution to this fast growing field of knowledge which now constitutes a well defined, highly technical branch of petroleum engineering.

Among the outstanding features included are the extensive sets of problems with answers, the clarity of presentation and the use of case histories from significant literature in the field. Also, attention is paid to units and numerical values and numerous examples used to illustrate and clarify topics covered.

It is a practical guide for calculating reservoir contents and recoveries with modern techniques for the analysis and prediction of recovery performance under a variety of production methods.

•

INVESTMENTS IN PRODUCING OIL ROYALTIES, Walter S. Sauchs & Co., Inc., Philadelphia, Carl S. Webber, M.A. and Walter S. Sauchs, Jr. B.A.

This book has two purposes: to acquaint readers with an investment field that is relatively unknown, and to give them the analytical tools with which they may determine the value of specific oil royalty investments and their part in the composition of an investment portfolio.

It is hoped that this book, which for the first time brings together descriptive and analytical information bearing on investment in producing oil royalties, and will be a helpful guide to all interested in this field.

•

THE GREATEST GAMBLERS, McGraw-Hill Book Company, New York, Ruth Sheldon Knowles, $6.

The Greatest Gamblers is the story of the remarkable oil men and the vast industry they have created—from its simple beginnings 100 years ago at Titusville, Pa., to the big-business oil operations of today.

Included in this are the wildcatters, the prospectors, the scientists, the hunch players. It is also the story of a prospectors' rush that has become an organized industry and is a lively and authoritative account of what is probably the most fascinating and adventurous business of all.

SYMPOSIUM ON EDWARDS LIMESTONE IN CENTRAL TEXAS, Bureau of Economic Geology, The University of Texas, Austin, F. E. Lozo, H. F. Nelson, Keith Young, O. B. Shelburne and J. R. Sandidge, $5.00.

Contains five papers prepared for use in connection with AAPG field excursion of March 13-14, 1959. Also includes pictures with explanatory description and 23 text figures.

•

INDEX OF OIL-SHALE AND SHALE-OIL PATENTS: 1946-56, A Supplement to Bulletins 467 and 468, U.S. Government Printing Office, Washington, D.C., Simon Klosky, 60 cents.

United States Patents: This bulletin contains nearly 300 U.S. patents that relate to retorting (and distilling underground), refining and utilization of oil shale and its products. The patents are arranged in numerical order, and an alphabetical list of inventors and assignees follows them.

•

INDEX OF OIL-SHALE AND SHALE-OIL PATENTS: 1946-56, A Supplement to Bulletins 467 and 468, U.S. Government Printing Office, Washington, D.C., Simon Klosky, 40 cents.

United Kingdom Patents: This part of Bulletin 574 contains 180 United Kingdom patents that relate to retorting (and distilling underground), refining and utilization of oil shale and its products. The patents are arranged numerically by country, and an alphabetical list of inventors and assignees follows them.

•

TWENTY-NINTH ANNUAL RESUME ROCKY MOUNTAIN OIL & GAS OPERATIONS FOR 1958, Petroleum Information, P. O. Box 2612, Denver, Colo., $10.

Petroleum Information's Annual Resume is the twenty-eighth published by the firm. The unique publication, which includes more than 100 pages of detailed statistical data on 1958 operations in the Rockies, as well as a 117-page narrative summary of regional activity, is available from Petroleum Information's offices and sales agents in Denver, Casper, Wyo., Billings, Mont., Durango, Colo., and Bismarck, N.D.

ACKNOWLEDGMENT

The article "New Developments in High Temperature Drilling Fluids" which appeared in the October issue of WORLD OIL was a condensed presentation of the paper "The Development and Testing of a High Temperature Oil Well Drilling Fluid." This paper was delivered at the ASME convention in Houston, Sept. 23-25, 1959.

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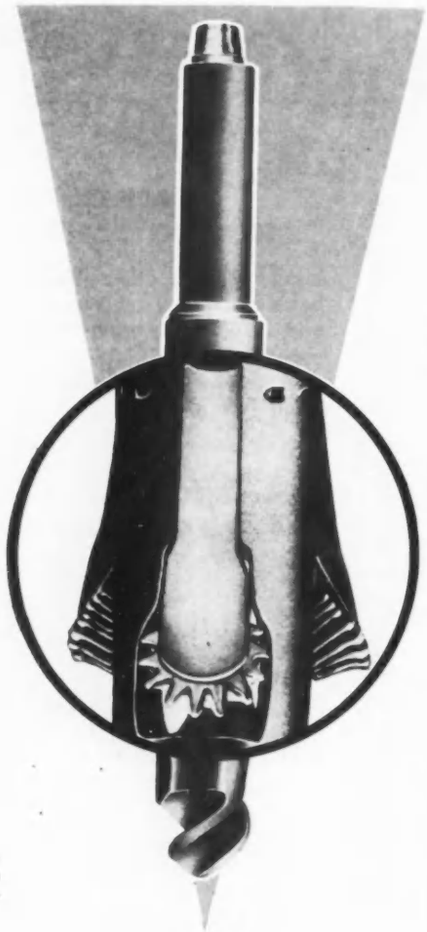

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SQUEAKS from the BULLWHEEL

"I think it's simply wonderful the way you oil men can squeeze all that oil out of a little dirt."

Down the Hall and Then . . .

"If you're looking for the manager's office," said the helpful girl at the reception desk, "just follow the passage until you come to a sign reading 'No Admittance.' Then go upstairs until you see the sign, 'Keep Out.' Follow the corridor until you see the sign 'Silence', then just yell."

The Range Rider

A Kansas woman tells of going to the city to attend a cattleman's convention. Determined to have something unusual to wear, she made a blouse and embroidered every cattle brand she knew on it.

In the hotel where the cattle folks stayed, she waited while her husband registered, noticing two old cattlemen giving her blouse the once-over. Finally one of them remarked in a loud voice, "That critter sure has changed hands a lot, ain't she?"

In Again, Out Again, Finigin

"How do you expect to get into Heaven?" the mother asked her naughty little boy.

"Why, I'll just go in and out and keep slamming the door until they say, "For goodness sakes, come in or stay out! Then I'll go in."

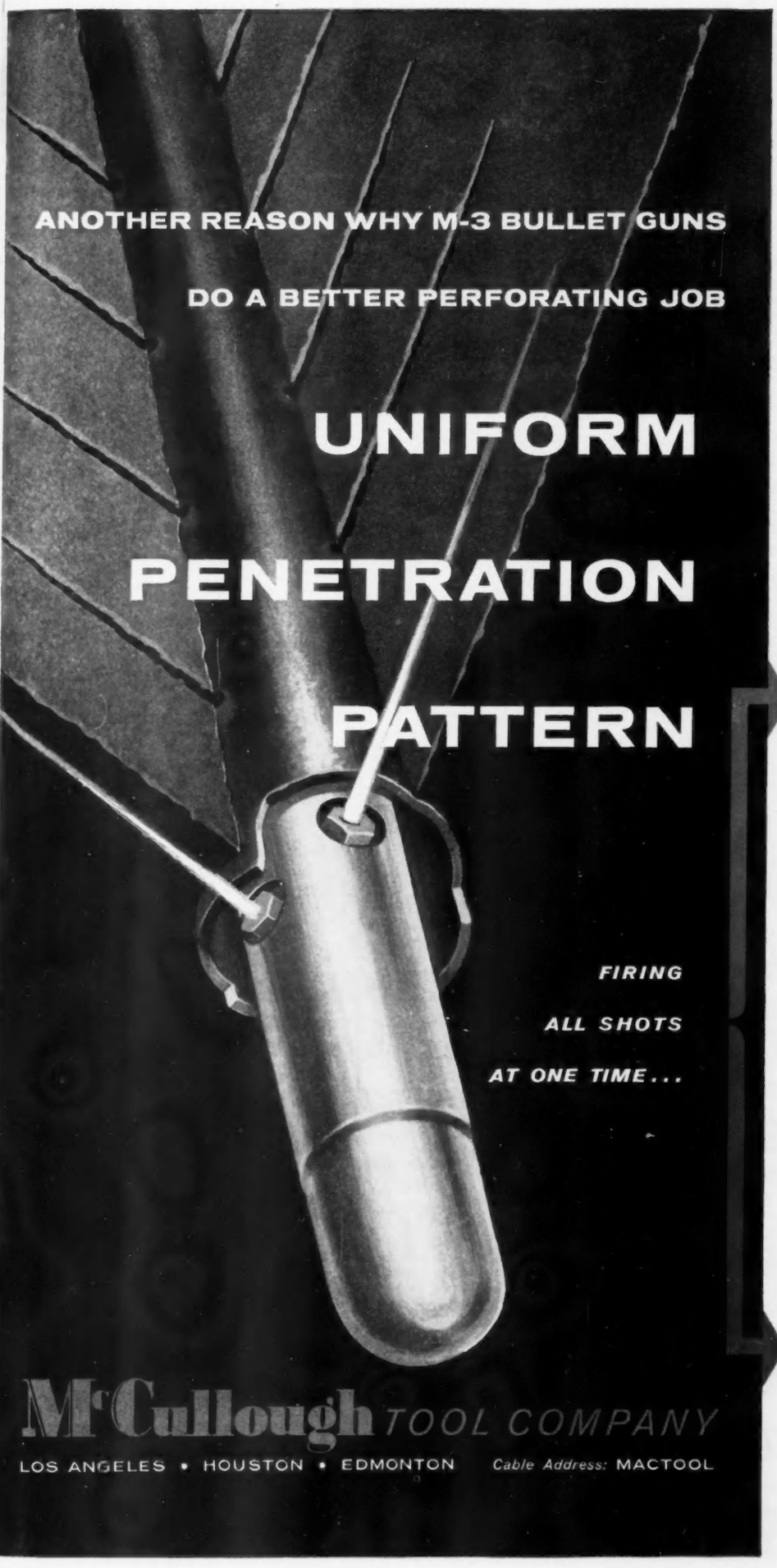
I Like Frog Legs, Too, But—

A biology professor was unwrapping a parcel before his class. He explained to his students that it was a fine specimen of a dissected frog.

Upon disclosing two sandwiches, a hard-boiled egg and a banana, he was nonplussed and muttered: "But surely I ate my lunch."

One in Every Crowd

Every baseball team could use a man who plays every position superbly, never makes an error . . . but there's no way to make him lay down his hot dog and come down out of the grandstand.

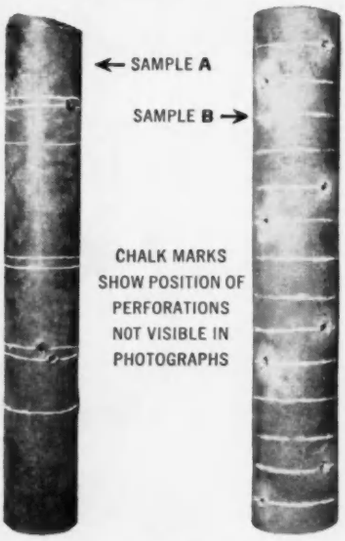


Deep, evenly spaced perforations that *uniformly* cover the productive zone – assure you of the most effective perforating job – and that's what you get when you shoot for production with McCullough M-3 Bullet Guns.

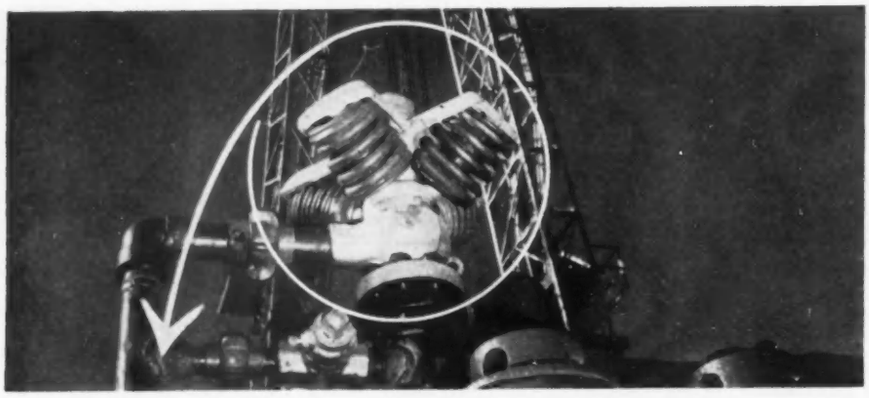
An M-3 Gun fires all shots at one time while the gun is motionless in the casing. Thus, perforations are the exact pattern of the chambers in the gun – in any shot density desired.

Combine McCullough's precise depth measurements with deep, evenly spaced perforations covering the *entire* pay zone and you get maximum drainage from formation to well bore – best possible production.

prevents bunching of shots in one small area in pay zone, giving insufficient coverage – prevents scattering of shots over a wide area, possibly missing the pay zone entirely. Sample A (actual photo of pipe recovered from well) shows the erratic shot pattern produced by a gun firing one shot at a time. As each shot is fired the upward thrust of released gases causes the gun to dance up and down.



eliminates the danger of possible pipe damage or failure. Too many perforations in one spot or in a coupling can cause pipe to part if it is in severe tension. Sample B is an actual example of six shots per foot fired by an M-3 Bullet Gun. Note the uniformity of shot pattern – no danger here of seriously weakening your casing, and you get the most productive perforating job possible.



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Operate rig circulation systems for maximum effectiveness — in complete safety — with Kinzbach Model 112 Mud Pump Relief Valves installed. You are assured instantaneous relief at set pressure with quick, automatic reset to maintain flow and pressure in partially blocked systems. When system is completely blocked, Kinzbach Pressure Relief Valves give full bypass for safety to pumps and other equipment.

Kinzbach Model 112 Pressure Relief Valve pressure range from 500 psi to 16,500 psi safely meets all drilling requirements including cementing and fracturing jobs. Available in 2" and 3" sizes. Write for complete catalog or see your Composite Catalog.

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What Bull in What China Closet?

The visitor was standing by watching the farmer milk a cow. Suddenly a bull charged toward them, but stopped suddenly just short of the farmer. The visitor dashed for cover but the farmer went on milking undisturbed.

"Aren't you scared?" the visitor gasped.

"No," the the farmer replied, "this cow happens to be the bull's mother-in-law."

Lucky, Lucky Herman

Two women who had not seen each other for a long time met on the street one day.

"Why, Mary," said one of them. "I see you got your new fur coat after all. I remember that you said your husband couldn't afford to buy one."

"So I did," replied the other, "but we had a stroke of luck. My husband fell and broke his leg, and the insurance company paid him $400."

Gentlemen Farmers

"If a farmer raises 5,000 bushels of potatoes and has to sell them at a dollar per bushel below parity, what does that mean to him?"

"A new Buick."

Marriage

After a few years of marriage, the young husband began to spend many evenings out with "the boys." One night his conscience bothered him so he called his wife from his office.

"Hello, darling," he said. "Slip on your party clothes and meet me downtown. We'll have dinner in some quiet place and then we'll see a show. How about it?"

"I'd be delighted to meet you, Henry," she replied. "But why not come out to the house and get me? There's nobody home."

Now hubbie spends every night at home. His name is Sam.

Jealousy

Every evening when he came home from work his wife went over his clothes with near-microscopic inspection. Smallest hair on his coat would lead to a frightful scene.

One night she found nothing, absolutely nothing, on his coat. She burst out in torrents of tears and sobbed: "Even bald women, now!"

No Resemblance

A wolf, lounging in a hotel lobby perked up when an attractive young lady passed by. When his standard "How-de-do?" brought nothing more than a frigid glance, he sarcasmed, "Pardon me, I thought you were my mother."

"I couldn't be," she said. "I'm married."

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Love of Life

Did you hear about the man 87 years of age who married a 19 year old girl? He died of a new disease called Ectasy. It took them three days to wipe the smile off his face.

'Where's Charley?'

A woman went into a cemetery manager's office: "I can't find my husband's grave. I know he's buried here."

"What's the name?" asked the manager.

"Charley Jackson," she replied.

Referring to his card index, the manager said, "Madam, we have no Charles Jackson. We have an Elizabeth Jackson."

"That's him," she said. "Everything's in my name."

Oh!, For Those Cavemen Days

The teacher asked her class for the difference between a primitive man and his modern counterpart.

"That's easy," returned the star pupil, "when his wife talks too much the modern man goes to his club, the primitive man just reached for it."

Semantics

A group of student nurses, creeping back to the hospital one night, met three internes at the gate.

"Shh," said a nurse, "we've been out after hours."

"Shh," said an interne, "we're going out after ours."

Future Business Man

The little boy dashed in and informed his mother breathlessly that he'd just sold their mongrel for $50,000.

"For cash?" inquired his mother.

"Well, almost," was the reply. "I swapped him for five $10,000 kittens."

Information Please

Letter to a correspondence column read: "I'm only 19 and stayed out until 2 o'clock the other morning. My mother objects. Did I do wrong?"

The answer was: "Try and remember."

Houdini Would Know

It's a mystery to us what a nudist does with the car keys after he locks it.

Caught Cat-Whipping

"Heard you were moving a piano so I came over to help."

"Thanks, but it's already upstairs."

"Did you move it alone?"

"Nope, hitched the cat to it and he drug it up."

"You mean your cat hauled that piano up two flights of stairs? How could a cat pull a heavy piano?"

"Used a whip."

If My Figures Are Correct

A drunk was sitting at a bar busily scribbling figures on some paper. The bartender was curious and asked what he was doing.

"Well, itsh like thish," said the lush. "My wife ish on a diet and she tol' me she'sh losing four pounds a week. She did weigh 168, and if my figures are correct, I'll be rid of her completely in 14 months."

Right Shoulder Arms ! !

Sgt.: "What's the first thing you do when cleaning your rifle?"

Private: "Look at the number."

Sgt.: "What in blazes for?"

Private: "To make sure it's my gun."

"We bought a pair because..."

In his own words, Ray Christian of Christian, Inc. and Christian Well Service Co., Ltd. said, "I was not under pressure to buy any certain make and – with today's competition the way it is – I had to have the best and most mobile drilling and servicing equipment available . . . to meet competition and still make a normal profit! So – we bought TWO Cardwell KM250s!"

Cardwell Model KM250 is equipped with every profit-making advantage possible – high mobility . . . 40 to 45 miles per hour on the highway . . . quick rig-up and down . . . and PLENTY OF POWER!

The KM250 is designed for servicing and workover in the 12,000 to 15,000 foot range with 2½-inch tubing – and has emerged as one of the FASTEST, most mobile drilling rigs for **profitable** drilling under today's footage prices, in the 5,000 - 6,000 foot range . . . and for slim hole drilling at even greater depths.

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6—5½" bore 7" stroke, 2000 PSI, flange mount
3—5" bore 2⅜" stroke, 2000 PSI, flange mount
6—7" bore 3" stroke, 2000 PSI, flange mount

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2—Telescoping, 60" stroke, Chrome Plate Sleeves 1½ N.P.T.

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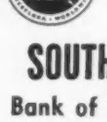

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SOUTHWEST FLORIST
Bank of The Southwest Bldg.
Houston, Texas
CA 5-6603
Cable Address:
SOUFLO, Houston, Texas

SITUATIONS WANTED

Former drilling contractor and oil producer that has recently sold out is interested in making contact with an individual, group or company to manage and supervise their oil and gas operations, domestic or foreign. Location immaterial. R. Makin, Box 1628, Petroleum Building, Hobbs, New Mexico.

HELP WANTED

SALESMAN WANTED

Well-established successful firm has opening in an expanding sales department for young man looking for an opportunity in sales work. Must be college graduate, not over 33, in good health, ambitious and not afraid of work. Oil industry experience desirable. The man we are looking for will be trained at home office before moving into sales work on basis of salary plus commission incentive and traveling expenses. Our own personnel know of this advertisement. Your reply will be confidential and should be sufficiently complete to merit contacting you for an interview. Address Box 200-W, WORLD OIL, Houston, Texas.

PROPERTY

NOTICE

Will participate with reputable operators in drilling proven oil and gas ventures, and buy interests in producing properties. Full details to:

DOMINION LEASEHOLDS LTD.
PETROLEUM BUILDING
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Canadian Independent Oil Company
Subsidiaries
Dominion Leasehold Operators Ltd.
Dominion Leaseholds Oil Co., Inc.

WORLD OIL
Classified Ads
Don't Cost,
They Pay

New Company Announced by Chicago Bridge & Iron Co.

Chicago Bridge & Iron Company, Chicago, has announced formation of a company in The Netherlands to erect large steel plate structures fabricated in that country. The company, headquartered in Rotterdam, is Chicago Bridge (Netherland) N.V.

The new organization is a subsidiary of Chicago Bridge Limited, London, England, which is a subsidiary of Chicago Bridge & Iron Company.

J. A. Martino Guest of Honor At Metals Industry Dinner

Joseph A. Martino, president of the National Lead Co., was the guest of honor at a $100 per plate dinner sponsored by the non-ferrous metals industry that was held October 15, at the Waldorf-Astoria Hotel, New York.

C. R. Cox, president, Kennecott Copper Co., served as campaign chairman. The dinner was for the benefit of the National Conference of Christians and Jews.

Highlight of the dinner event was the presentation of the Brotherhood Award of the National Conference to Martino "for distinguished service in the field of human relations." The presentation was made by Admiral Lewis L. Strauss, former U.S. Secretary of Commerce, who serves as the national co-chairman of the conference.

Stockholders Re-elect All Directors of Sargent Engineering

Stockholders of Sargent Engineering Corporation unanimously re-elected all directors of the company at the annual meeting which was held in August.

The directors are E. J. Sargent, chairman and chief executive officer; S. B. Sargent, president; and G. L. Sargent, secretary-treasurer.

STATEMENT REQUIRED BY THE ACT OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933, AND JULY 2, 1946 (Title 39, United States Code, Section 233) SHOWING THE OWNERSHIP, MANAGEMENT, AND CIRCULATION OF WORLD OIL, published monthly at Houston, Texas, for October, 1959.

1. The names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Wm. G. Dudley, 4742 Banning, Houston, Texas; Editorial Director, Donald E. Kliewer, 7546 El Rancho, Houston, Texas; Managing Editor, Wallace Fitzgerald, 5423 Lymbar, Houston, Texas; Business Manager, R. M. de Sombre, 4410 Ingersoll, Houston, Texas.

2. The owner is: The Gulf Publishing Company, Houston, Texas; June Wooden Bliss, Houston, Texas; June Wooden Dudley Bliss—Trustee, Houston, Texas; Mrs. Grace C. Carter, Dallas, Texas; Mrs. Margaret D. Cashman, Beaumont, Texas; Drum & Company, c/o Trust Department, Houston, Texas; P. Stinson Dudley, Abilene, Texas; Ray L. Dudley (Deceased), Houston, Texas; Wm. G. Dudley, Houston, Texas; Wm. V. Gross, Austin, Texas; Mrs. Carolyn Dodson Keeble, Abilene, Texas; Mrs. Anita S. Lane, Houston, Texas; Charles H. Lane, Houston, Texas; James William Nelson, Baytown, Texas; Tom W. Nelson, Houston, Texas; Mrs. Sallie Windham Ridley, Houston, Texas; Walter Gage Sterling—Trustee, Houston, Texas; O. R. Waller, Chicago, Illinois.

3. The known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities are: NONE.

4. Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner.

R. M. de SOMBRE
Business Manager

Sworn to and subscribed before me this 16th day of September, 1959.

P. J. AUCOIN
(Seal) Notary Public in and for Harris County, Texas.
(My commission expires June 1, 1961)

CONCENTRATION

Concentration on the needs and requirements of the oil producer—careful, expert attention to the demands of modern production financing — these are reasons why Republic is a leading oil bank of the South — with the South's largest Oil Department. How may we serve you?

REPUBLIC NATIONAL BANK
OF DALLAS

CAPITAL AND SURPLUS $100,000,000 • LARGEST IN THE SOUTH

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

"I've ALWAYS preferred KING GA SWIVELS"

King Swivels 32GA and 53GA have been popular for many years. They have proved to be rugged, dependable and durable, and are in use around the world because they are "preferred". The fact that King Oil Tools is the largest manufacturer of lightweight swivels is supporting evidence of King engineering, service efficiency and complete all-around dependability.

INDUSTRY RECOGNIZES KING GA SWIVELS BY THESE FAMOUS FEATURES:
- ALLOY STEELS assure strength with minimum weight.
- PACKING is V-type, often called chevron type.
- WASHPIPES are seamless alloy tubes, case-hardened and ground.
- GREASE LUBRICATION for the packing.
- MULTIPLE BALL BEARING UNITS provide ample capacity.
- OIL BATH LUBRICATION for the bearings.
- Choice of BAIL OR ELEVATOR SHANK.

FOR FULL INFORMATION ON ALL KING SWIVELS — SEE YOUR NEAREST DISTRIBUTOR — OR WRITE:

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Cut Vapor Losses . . . Increase Profits . . .

Enardo In-Line Vent Valves

A positive means of maintaining a predetermined pressure in storage tanks . . . used in conjunction with Enardo pressure-type hatches.

Actual Case Histories . . .

Operating studies of companies which have installed Enardo Vapor Control Systems show how quickly you can increase profits by cutting vapor losses and gravity drop. Detailed information available on request. Write for Vapor Control Equipment Catalog.

ENARDO Box 1647, Tulsa, Okla.

What's New in EQUIPMENT and SERVICES

Drilling - Production - Exploration

Rotary Reamer Cutter

A new rotary reamer cutter, utilizing tungsten carbide compacts, has been introduced for reaming in the harder formations. Compacts are harder than formation being drilled; enables cutter to crush harder rocks. Cutter insures full gage hole at the reamer, increases bearing life, provides "under reaming" of the hole, and increases wear resistance of the outside of the cutter. (Drilco Oil Tools, Inc. Supplements data on Pages 1577-1581, 1958-1959 Composite Catalog).

For more data, circle E1 on postcard

New Tubing Joint

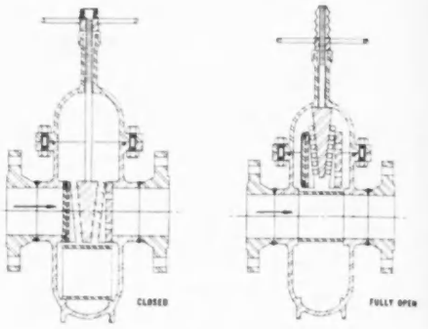
Increasing use of slim hole drilling techniques has led to the introduction of a new tubing joint with the smallest outside diameter of any threaded and coupled 2⅜-inch external upset tubing. Suitable for use in wells with average pressures. When both pipe and coupling are the same grade, joint efficiency is nearly 100 percent. (Jones & Laughlin Steel Corp. Supplements data on Pages 2773-2792, 1958-1959 Composite Catalog.)

For more data, circle E2 on postcard

Oil Level Switch-Gage

An oil level switch-gage that gives a visible oil level check while the equipment is running is now available. This sight switch-gage is combined with safety shutdown or with an alarm for use on crankcase, pump gearcase or oil reservoirs. It is easy to install and can be placed on multi-cylinder as well as single cylinder engines with little effort. (Frank W. Murphy, Manufacturer, Inc., Supplements data on Pages 3533-3535, 1958-1959 Composite Catalog).

For more data, circle E3 on postcard



New Anti-Friction Unit

A new anti-friction unit for gate valves that employs a self-sealing synthetic rubber seal gasket has been made available. Unit consists of a tapered wedge assembly mounted on roller bearings that controls the movement of the valve discs. New assembly assures higher working pressures, is drop tight and eliminates the need for mechanical operators. (Charles Wheatley Company).

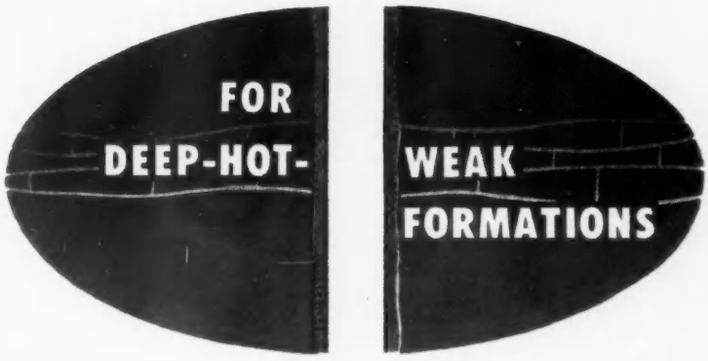
For more data, circle E4 on postcard

New Type 'R' Piston

A new Type "R" piston for slush pumps is now available. These pistons are designed for longer "mileage" and are available in either "Arrowprene" (oil and heat resistant compound), or natural rubber. (Arrowhead Tool Company).

For more data, circle E5 on postcard

SELECTIVE CEMENTING IN 2 OR 3 STAGES SAVE CASING AND CEMENTING MATERIALS



...with the precision designed and universally recognized multiple purpose cementing tool – the Halliburton "DV" Multiple Stage Cementer. With this tool, multiple stage cementing is no longer limited by well *depth, temperature,* amount of *cement* to be used, *pump pressure, circulating time* while landing casing, or final *well pressure* both *inside or outside* casing.

This precision built cementing tool incorporates a novel principle of hydraulics and use of two steel sleeves which allow precise cement slurry placement and control to effectively place two or three stages of cement on the outside of one string of casing at selected points *with multiple savings.*

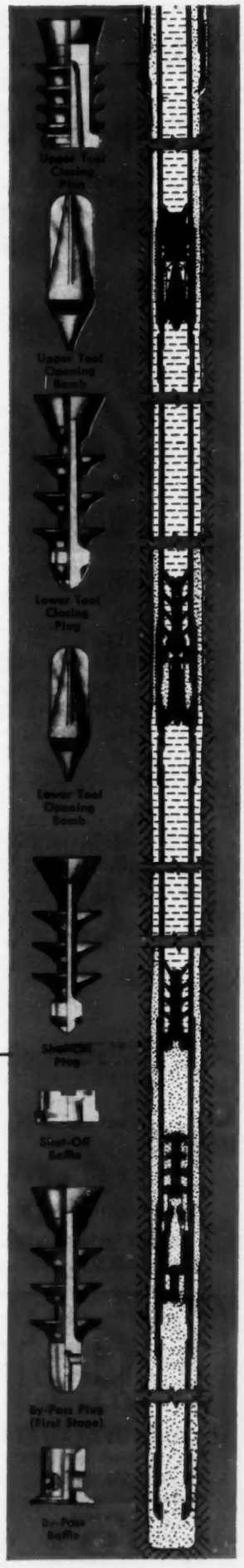
The basic uses of multiple stage cementing are:

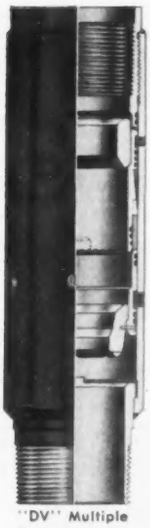
- Full Depth Cementing
- Dual Zone Well Completion
- Cementing widely separated formations
- Reduction of Pump Pressure
- Minimizing Loss of Cementing Slurry to Thieving Formations
- Reduction of Channeling

One "DV" Two Stage Cementer and set of Bomb Type or Displacement Type Plugs is required for two stage cementing. Two "DV" Three Stage Cementers and set of special plugs are required for three stage cementing as illustrated.

Halliburton "DV" Multiple Stage Cementers with plugs are available in tubing or casing sizes ranging from 2½" EUE to 13⅜" O.D.

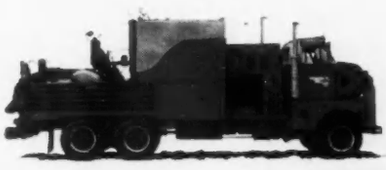
Your nearby Halliburton Representative knows the multiple benefits of Halliburton Multiple Stage Cementing... let him discuss them with you... it may save you time and money on your next deep, hot or weak formation well completion.





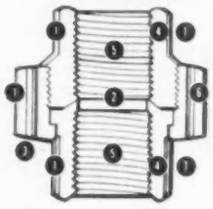
"DV" Multiple Stage Cementer

HALLIBURTON
CEMENTING SERVICES
HALLIBURTON OIL WELL CEMENTING COMPANY • Duncan, Oklahoma



284 SERVICE CENTERS – JUST MINUTES AWAY FROM ANY WELL

the INSIDE STORY of Capitol's F.S. UNION



1. Definite octagon for better wrenching surface
2. Burnished female seat assures repeated make-up
3. CAP trade mark—size and pressure marked
4. Heavy wall to exceed 3000# pressure demands
5. Extra threads, Army-Navy gauged to assure tight joint every time
6. Electro-zinc plated
7. Phosphate coated

INDIVIDUALLY PRESSURE TESTED
to assure perfect seat

COMPARE material and workmanship . . . Capitol F. S. unions meet ASTM-A105, Grade II. Each is clearly identified for 3000# CWP or 900# steam pressure, size, and stamped with the CAP trade mark.

Available in all sizes for ⅛" to 2" inclusive, either screwed or socket weld. Conveniently packaged with color-coded labels for easy handling and positive identification.

Only by actual comparison can you fully appreciate the extra quality engineered into the Capitol 3000# F. S. union. Designed and produced by fittings specialists to meet industry's most exacting demands.

SOLD ONLY THROUGH RECOGNIZED DISTRIBUTORS

CAP CAPITOL
MANUFACTURING CO.
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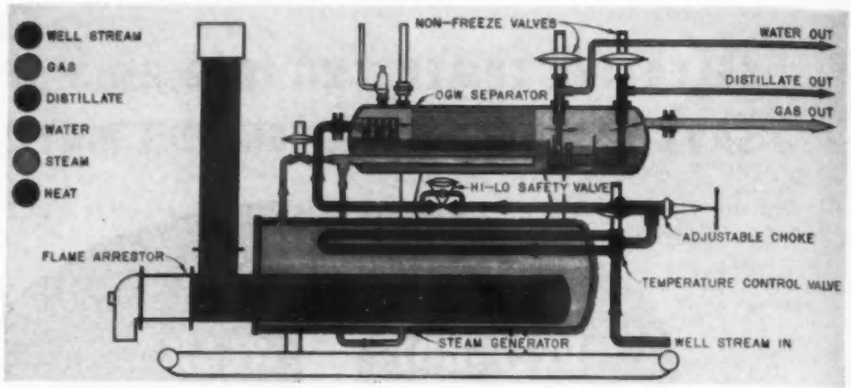
COLUMBUS, OHIO

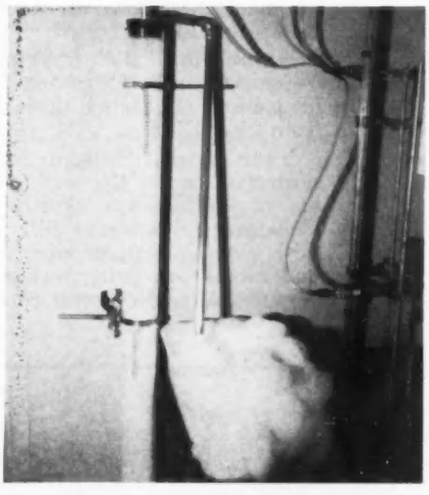
COUPLINGS — NIPPLES — UNIONS — BUSHINGS — PLUGS — REDUCERS — CAPS—CAPADAPTERS—WELL SUPPLIES



New Separation System

The National steam generating "Production Pak" is a pre-piped, skid-mounted, three-phase separation system with a steam generator. This production unit is especially designed to produce wells that require pre-heat before choking down to separator pressures. Automatic controls and valves maintain absolute control over water bath temperatures and sales gas leaving separator. (National Tank Co. Supplements data on Pages 3669-3688, 1958-1959 Composite Catalog.)

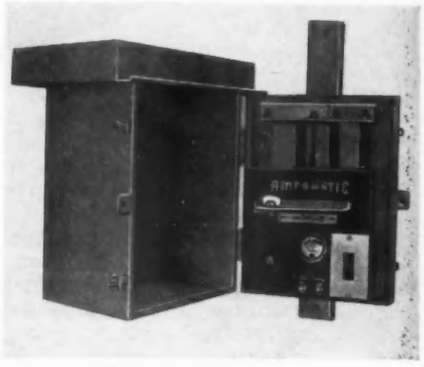
For more data, circle E6 on postcard



New Foaming Agent

Howco-Suds, a new foaming agent, is a water-soluble surfactant that imparts a low surface tension to all types of water and is capable of producing large volumes of foam under a variety of conditions. Can be used to regain the return of balled cuttings and also give continuous foaming action during drilling. Howco-Suds added to fracturing water aids in recovery of the water. (Halliburton Oil Well Cementing Co. Supplements data on Pages 2177-2284, 1958-1959 Composite Catalog.)

For more data, circle E7 on postcard



Cathodic Protection Rectifier

The new Good-All "Amp-O-Matic" eliminates the need to adjust rectifier output when a gully washer or a dry spell changes ground bed resistance. Amp-O-Matic adjusts the output itself, compensating for changes in ground bed or stack resistance. Has no moving parts, is extremely resistant to lightning damage and cannot be overloaded. Available in 110, 220, 440, 115/230 or 220/440 volt range. Single phase input. (Good-All Electric Mfg. Co.).

For more data, circle E8 on postcard

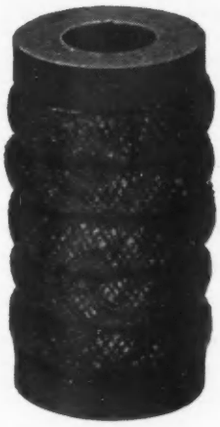
Rig and Pump Drive Groups

New lightweight rig and pump drive groups for use with engines supplying up to 300 hp are available. They are known as National Types B- and BT-18-1¼Q Drive Groups, with mechanical or torque converter drives. Features include 12-inch high beam frames, 18-inch air-flex engine clutches, 1¼-inch quadruple compound drive chains, 5-foot 10-inch frame centers and 22-foot long frames. (The National Supply Co. Supplements data on Pages 3549-3668, 1958-1959 Composite Catalog.)

For more data, circle E9 on postcard

NO OTHER PACKING LASTS AS LONG

MARLO Polished Rod Packing is the most cost-cutting and long-lasting packing found in any oil field, anywhere.



RW-6E Sets for Round Stuffing Boxes

1 MARLO outlasts ordinary packing up to 8 and 10 times, and *more.*

2 MARLO saves oil, reduces wear on rods, saves labor.

3 MARLO does not harden or burn during pump-off.

4 MARLO is anti-frictional. Its resilient, corrosion-resistant, semi-metallic rings form a dense, shock-absorbing, bearing-like surface.

5 MARLO has been proved in the field and standardized on by more and more leading producers.

Available in all regular sizes

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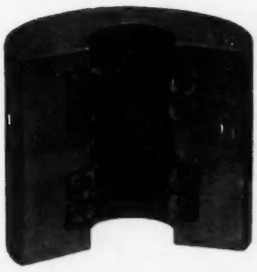
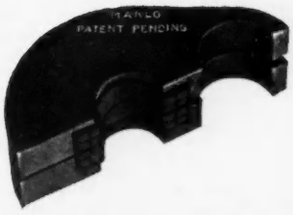
MARLO IMPROVED PACKINGS FOR HERCULES AND RATIGAN STUFFING BOXES

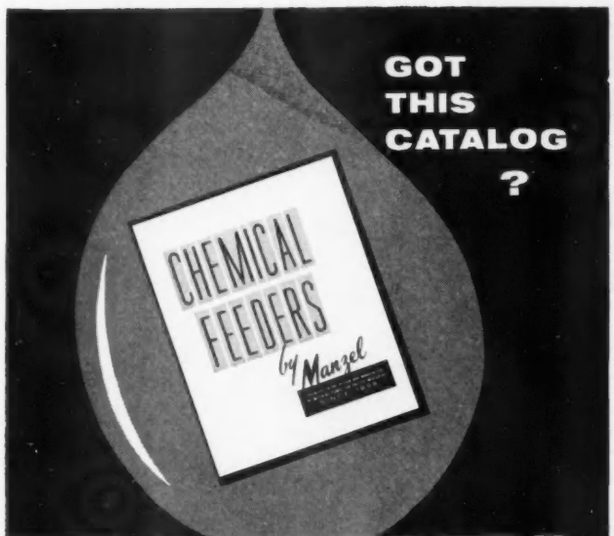
with vitalizing, semi-metallic inserts. Immensely longer life under toughest conditions. The only truly modern designs. In all standard sizes.



For **HERCULES** Stuffing Boxes



For **RATIGAN** Stuffing Boxes



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Here's the most complete, most useful catalog on metering pumps ever published. Lets you select the **exact** unit you need to meet any requirement. Ask your Manzel field engineer . . . or write direct for YOUR FREE COPY.

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281 Babcock Street
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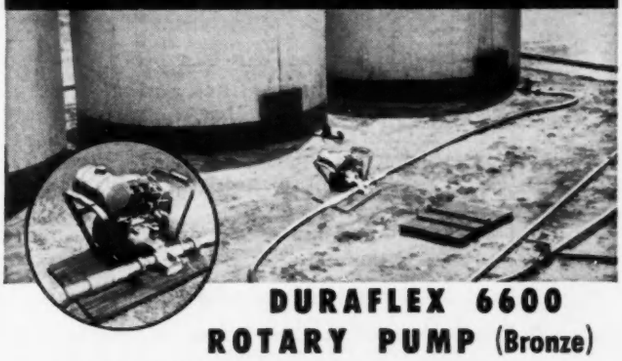
Specialists in metering pumps and lubricators since 1898

TANK BOTTOM CIRCULATING

Plus Transfer of Treated Oil



DURAFLEX 6600 ROTARY PUMP (Bronze)

- **DOES NOT EMULSIFY THE FLUIDS**
- **PUMPS AS LOW AS 17 GRAVITY CRUDE**
- **PORTABLE:** The ONE PUMP that can be used for almost every pumping job: • Brine Disposal • Rig Supply • Fire Fighting • Paraffin Removal

Pumps a barrel of oil a minute at 150 psi yet weighs only 101 lbs. Belt, or motor, or engine driven (Kohler or Wisconsin).

USED THROUGHOUT THE OIL PATCH.
Parts and Service Everywhere.

Get One At Your Supply Store NOW!

MP PUMPS

MARINE PRODUCTS CO.
644 LYCASTE AVE. • DETROIT 14, MICH.

"Sour Crude or Salt Water Can't Corrode Our VAN-COR Pipe Lines"

Men in the oil fields find Van-Cor pipe, fittings, and valves are ideal for gathering lines, gas lines, and salt water disposal. That's because Van-Cor is 100% unplasticized polyvinyl chloride that is highly resistant to acids, alkalies and paraffin adherence. Van-Cor also offers these important advantages:

1. Light weight (½ that of aluminum). This insures portability and ease of handling.
2. Easily installed; high tensile strength; low flow resistance.
3. Readily formed, machined, threaded and welded.

Available in normal and high impact types.

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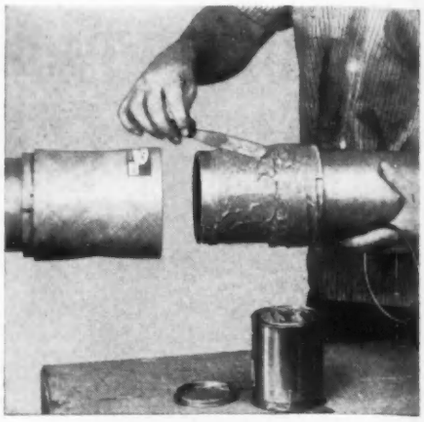


Corrosion-Resistant Fittings

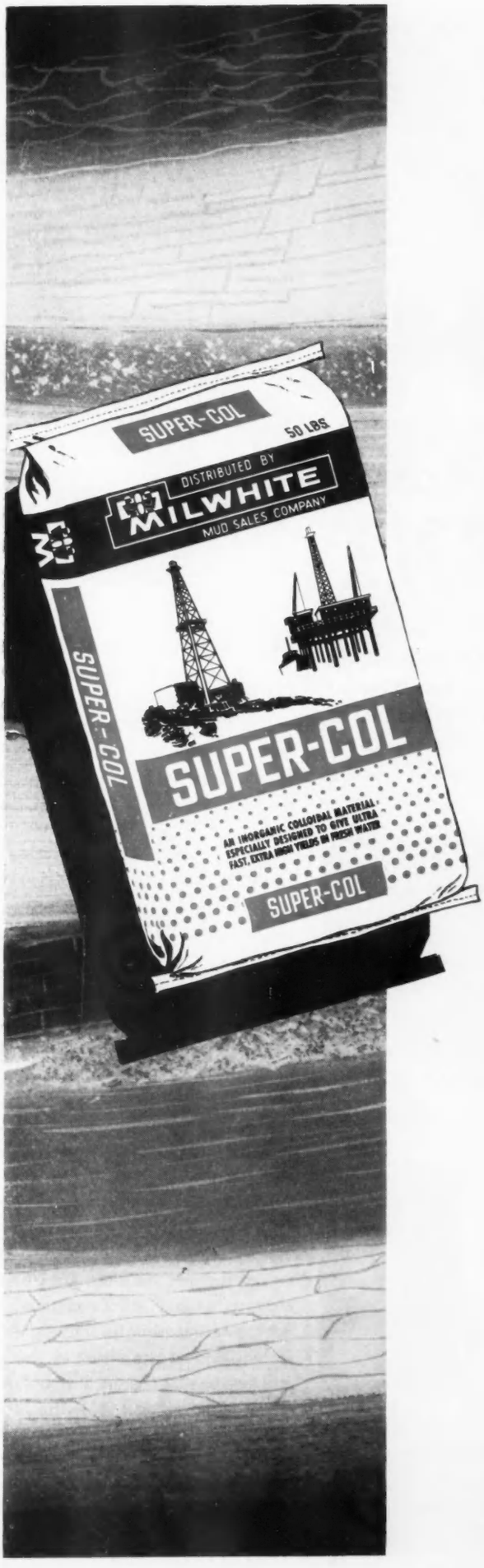
Bondstrand, the reinforced plastic pipe, offers corrosion-free service in the transmission of water, salt solutions, sulfide water, petroleum hydrocarbons, solvents and other chemical solutions. New fittings include 90 and 45 elbows, tees, couplings and other fittings for either threaded-end or plain-end Bondstrand pipe. Bondstrand pipe comes in rigid 20-foot lengths in 2-inch and 8-inch diameters. (Amercoat Corporation.)

For more data, circle E10 on postcard

Well Casing Vise-Lok

A new positioning limit clamp for well casings is now on the market. Called the Halliburton Vise-Lok, the new device allows well-head clamping without welding. Vise-Lok is completely forged for extra strength, since it must withstand extreme loads. It is also fully machined to close tolerances. (Cleveland Forge Works, Forge and Fittings Division, H. K. Porter Company, Inc.)

For more data, circle E11 on postcard



YOU'LL BUILD BETTER AND MORE ECONOMICAL MUD SYSTEMS WITH

SUPER-COL

(packaged in 50 lb. bags.)

MILWHITE SUPER-COL SAVES MATERIAL

Pound for pound, Super-Col will give you twice the viscosity in fresh water, in water containing up to 2½ % salt, and in water containing up to 240 ppm calcium.

MILWHITE SUPER-COL SAVES RIG TIME

A fast rate of yield and a minimum amount of required mixing makes Super-Col invaluable when a pit of mud is needed "in a hurry".

MILWHITE SUPER-COL SAVES MONEY

Its efficient performance can save you 25% or more in mud cost as compared with Wyoming Bentonite.

MILWHITE SUPER-COL IS STABLE AND PERMANENT

This material has been tested at temperatures of 350° F. for as long as seven days with little or no change in viscosity.

MILWHITE SUPER-COL IS A SPACE SAVER

From offshore operations to rigs located great distances from the source of supply, large savings in storage space and transportation charges will be realized by using Super-Col.

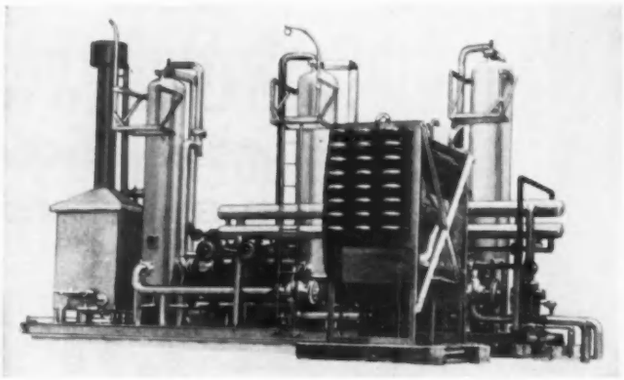
Drilling Progress through Mud Research
is continuous at Milwhite

MILWHITE

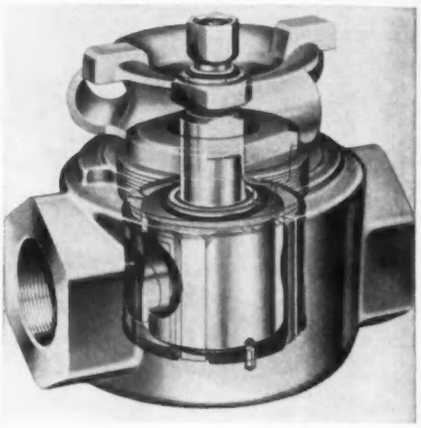
MUD SALES COMPANY
HOUSTON, TEXAS
DIVISION OF MISSISSIPPI RIVER FUEL CORPORATION

New Dynamic Adsorption Unit

This dynamic adsorption unit DAU Type 3 gives a capacity for twice the hydrocarbon recovery according to the manufacturer. Better performance and increased recovery is possible by the use of a third tower to preheat the gas before it enters heating cycle. Recovery through a unit with two towers operating on 35-minute cycles was 11 bpd. Three-tower unit, operating on 13-minute cycles, is 22 bpd. (The Parkersburg Rig & Reel Co. Supplements data on Pages 4005-4044, 1958-1959 Composite Catalog)



For more data, circle E12 on postcard



Non Sticking Plug Valve

A new valve has been developed which reportedly is stronger and 40 percent lighter than conventional tapered plug valves. Valves requires approximately 50 percent less turning force, can be overhauled in the lines and, can be used in lubricated or non-lubricated services. The new valve never needs adjustment and cannot stick because unlike most high-pressure plug valves, it is not tapered. (Hamer Valves, Inc., Supplements data on Pages 2290-2291, 1958-1959 Composite Catalog).

For more data, circle E13 on postcard

Bottom-Hole Pressure Gage

An improved high precision bottom hole pressure bomb which is saving oil companies money in petroleum production is now available. The instrument, known as the Amerada RPG-3 gage, accomplishes this feat by giving bottom-hole pressure readings to within .05 percent accuracy. The gage is unique among bottom-hole pressure instruments in that it utilizes a helix-wound bourdon tube made of Ni-1 Span C Tubing to transmit directly the effects of pressure to a recording stylus. (Geophysical Research Corporation, a Subsidiary of Amerada Petroleum Corporation).

For more data, circle E14 on postcard

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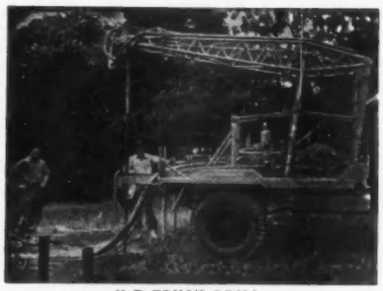
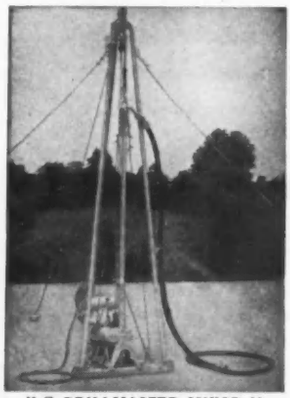
H-E manufacture a wide range of Geophysical supplies in addition to that illustrated including: loading poles, cable reels, winches, shooting trucks etc. Write for full details quoting ref.D/GL.



H-E TRUCK DRILL



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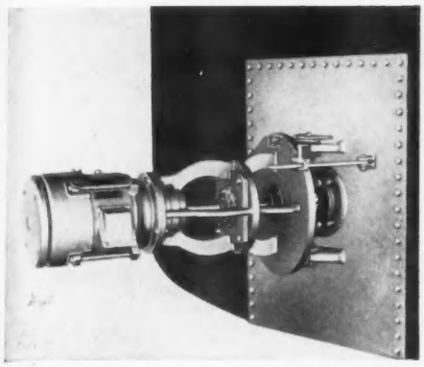
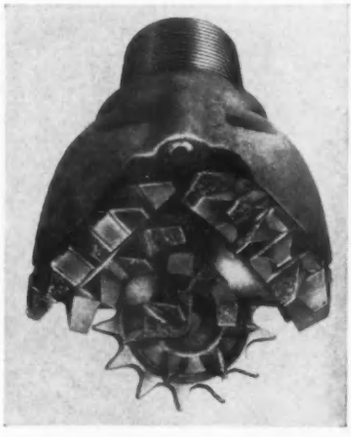


New Lease Tank Mixer

A new lease tank mixer, developed to resuspend paraffin in 500 through 3,000-barrel tanks has been announced. It is particularly adaptable where it is desirous or necessary to keep the tank in continuous service. The drive unit is separable from the tank unit and a single driver may be used on several tanks at one location. Mixer entrance angle can be changed through a total of 40 degrees. (Jensen Engineering Company.)

For more data, circle E15 on postcard



New Rock Bit

A new rock bit designed specifically for soft top-hole formations is reported drilling up to 30 percent more footage and at 18 percent faster rate of penetration than bits previously used. New OSC-3A features an increase in tooth height, resulting in deeper "bite," speeding penetration. Fewer number of teeth make contact on bottom, increasing the gouging-scraping action. (Hughes Tool Co. Supplements data on Pages 2413-2500, 1958-1959 Composite Catalog.)

For more data, circle E16 on postcard

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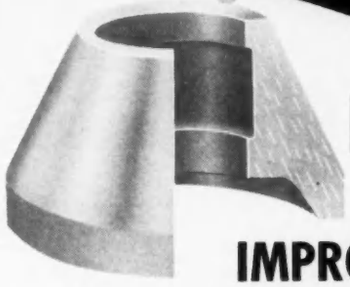
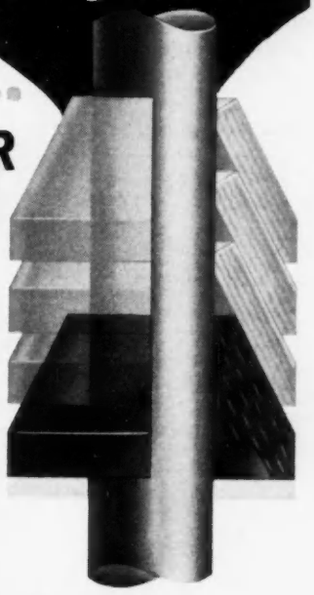


NOW... ANOTHER IMPROVEMENT



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For more data, circle E17 on postcard

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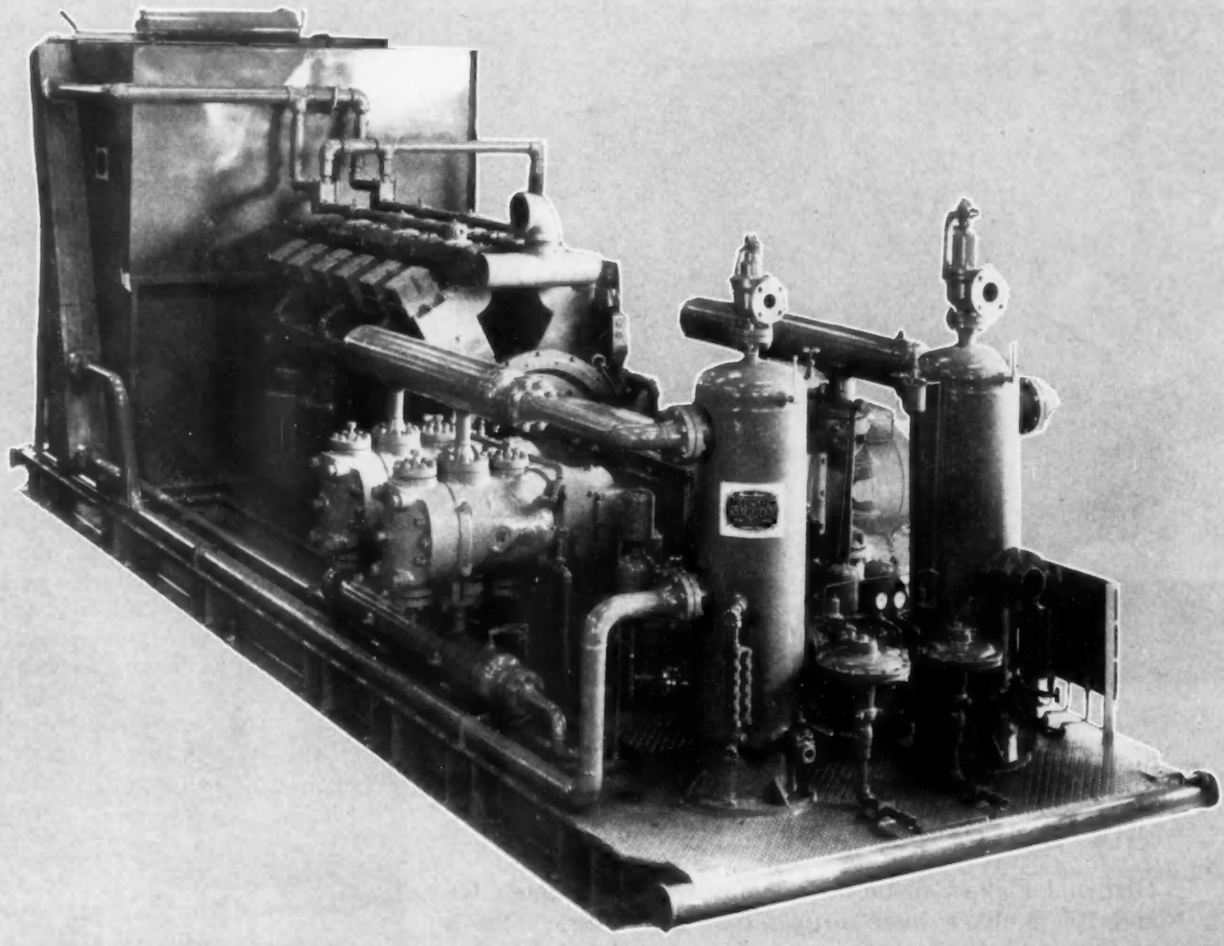
For more data, circle E18 on postcard

New Derrick String-A-Lite

This oil derrick String-a-lite has been completely redesigned. Various stock assemblies are offered in combination to form vapor-proof lighting sets tailored to fit rigs using mast or derrick. Features include all-neoprene latching connectors which can't rust, corrode or deform; combined with compact floodlights and molded neoprene headlamps. (Joy Manufacturing Co., Baash-Ross Tool Co. Division. Supplements data on Pages 285-416, 1958-1959 Composite Catalog.)

For more data, circle E19 on postcard



WILSON SUPPLY HHE INGERSOLL-RAND

The Wilson Supply HHE unit illustrated above is a 9" x 9" x 4½" x 4½" x 5" compressor, but there are other sizes available to handle a wide range of applications.

An additional feature of the new Wilson Supply HHE unit is the Channel Valves. Proved by service in thousands of Ingersoll-Rand compressors, these "cushioned" Channel Valves are quiet, efficient and durable.

For complete information on the new Wilson Supply-Ingersoll-Rand HHE Packaged Compressor contact your nearest Wilson Supply Store or write: Compressor Department, Wilson Supply Company, P O. Drawer 19, Houston, Texas. Please include suction, discharge and volume to be handled.

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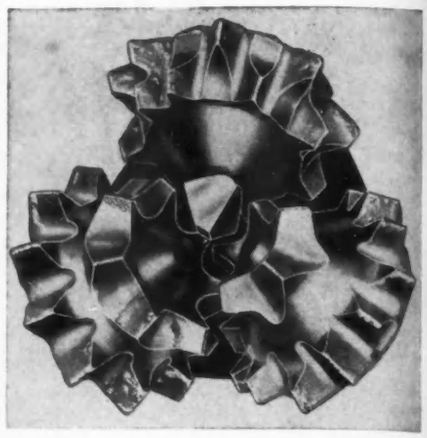
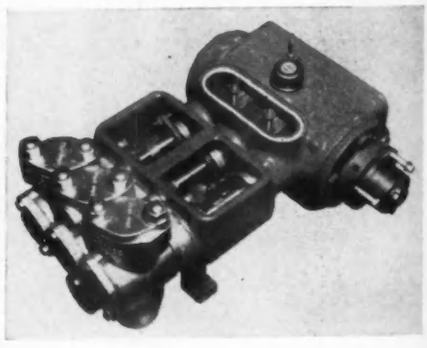


Fast Penetration Bit

Known as the W3SC, this new bit is designed for the fastest penetration in soft strata and in hard layers which often require several round trips if drag bits are used. Will penetrate soft formations to 150 feet or more per hour due to wide spaced teeth and ventilated jet action which overcome balling up. Ideal for maximum footage in soft shales, clay, broken shale, salt, shells and soft limestone. (Oil Tool Mfg. Co. Supplements data on Page 3781, 1958-1959 Composite Catalog.)

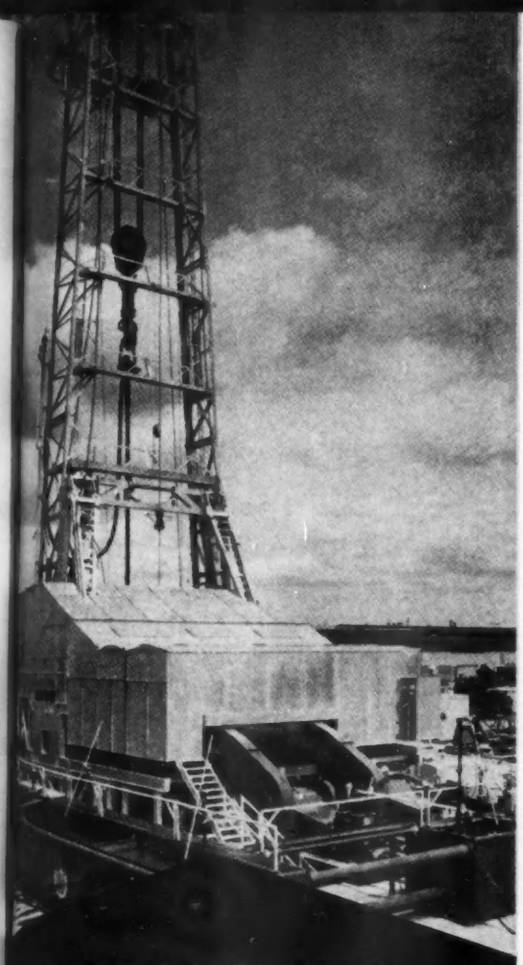
For more data, circle E20 on postcard



Power Plunger Pump

A new power plunger pump designed specifically for salt-water disposal is now being marketed. The P-175 is a 14-hp triplex pump with a 1¾-inch stroke. Interchangeable plungers may be used to produce volumes to 936 bpd, pressures to 1,780 psi. The pump measures 27⅜ inches long by 21¾ inches wide by 12 5/16 inches deep and weighs just 395 pounds. (Frank Wheatley Pump and Valve.)

For more data, circle E21 on postcard



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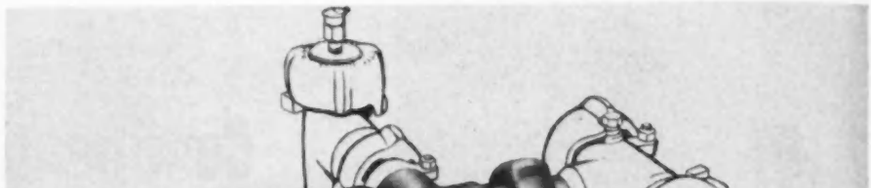


New Safety Valve

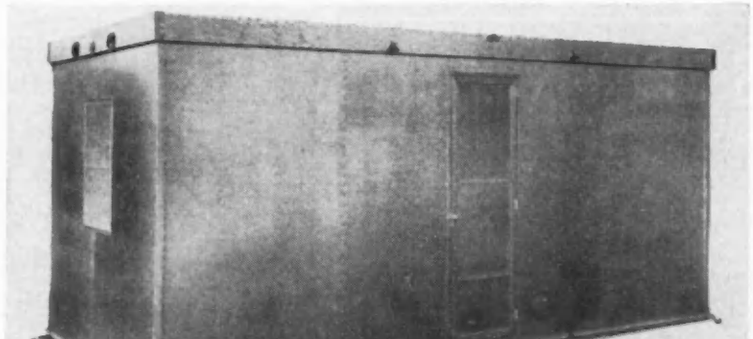
An innovation in automatic safety valves has been made available which makes use of an old engineering principle, i.e., a large piston exposed to low pressure can be balanced against a small piston exposed to relatively high pressure. The Balance Pressurematic Valve can be attached to any regular 2-inch Tee Type Unibolt valve body, or Positive Choke body. (Thornhill-Craver Division Supplements data on Pages 4917-4944, 1958-1959 Composite Catalog).

For more data, circle E22 on postcard

Electric Recording System

This new electric recording system, known as Drilloger, gives complete and permanent records of the day's drilling operation, and presents it in a neat manner, accurate and easily interpreted. It combines the accuracy and sensitivity of laboratory instruments, yet operates under rugged conditions. Recorders are equipped with one, two or four channels. (Martin Decker Corp. Supplements data on Pages 3173-3200, 1958-1959 Composite Catalog.)

For more data, circle E23 on postcard



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For more data, circle E24 on postcard

Retrievable Gas Lift Valves

New models of retrievable gas lift valves have been added to Macco's line of wireline retrievable equipment. The new CM1-FS-CK fluid operated gas lift valve is actuated by a predetermined hydrostatic fluid head in the tubing. Designed primarily for lifting multiple completions utilizing the tubing casing annulus for a common reservoir of supply gas. (Macco Oil Tool Co., Inc. Supplements data on Pages 3125-3127, 1958-1959 Composite Catalog).

For more data, circle E25 on postcard

Literature

To get your copies, circle key numbers on postcard and mail to WORLD OIL

Orifice Plate Catalog

Daniel Orifice Fitting Company has available a new Catalog Section "G" on orifice plates, sealing units and ring-type joint plate holders. Universal size orifice plates for use in Daniel orifice fittings are included, as well as paddle type orifice flange plates and plates for Daniel flow sections.

To get a copy, circle E26 on postcard

New National Bulletins

A new general reference guide to National wellhead equipment and a catalog of all National multi-string wellhead equipment are now available in bulletins 510 and 506 from The National Supply Company.

To get a copy, circle E27 on postcard

Fishing Tool Bulletin

The new jet-powered junk retriever of Wilson Supply Co.'s Fishing Tool Division is described in a new bulletin. The four-page folder describes operation of the junk retriever plus a field case history.

To get a copy, circle E28 on postcard

Acid Guide

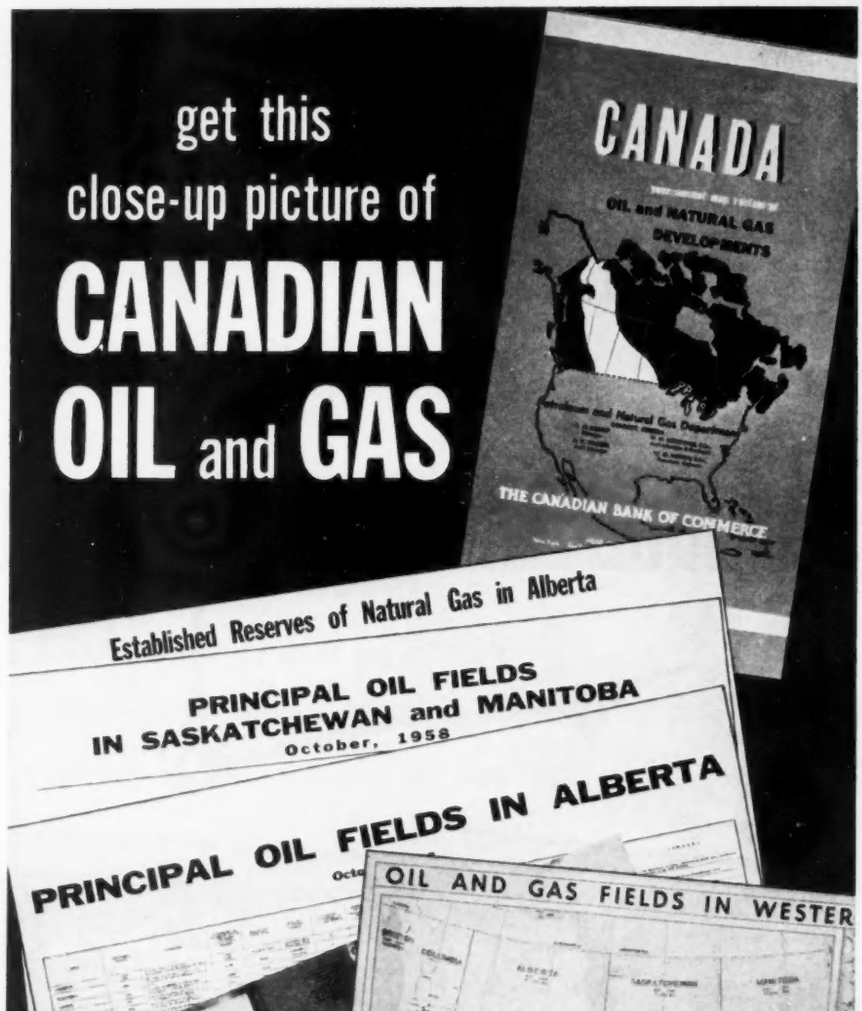
Dowell Division of The Dow Chemical Company announces a new engineered technique called the "Acid Guide" to forecast results of acid treatments. Based on detailed well and laboratory data, the "Acid Guide" makes it possible to predict the advisability of acid treatment for a specific well.

To get a copy, circle E29 on postcard

Consolidated Rig Bulletin

The National Type 55 Consolidated rig is described in a new bulletin offered by The National Supply Company. The 16-page bulletin, No. 384-B, includes completely revised drive group sections and changes in rig ratings.

To get a copy, circle E30 on postcard



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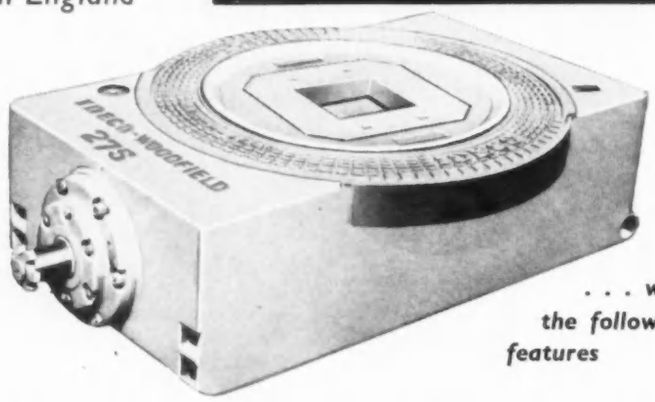

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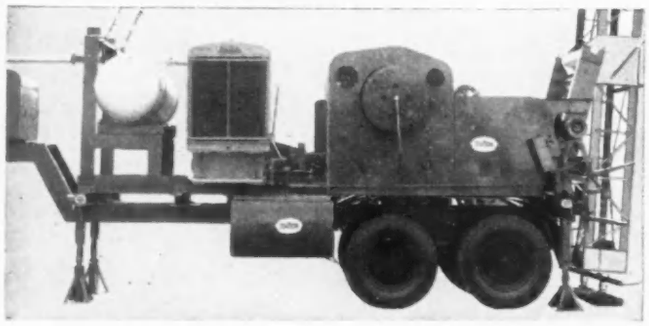

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New Drill Pipe Brochure

An eight-page brochure on seamless drill pipe has been issued by The Youngstown Sheet and Tube Company. It provides information on the complete range of weights, sizes and grades. Charts show physical properties dimensional, torsional, collapsible and tensional and illustrations of upset drill pipe for attachment of welded and threaded tool joints.

To get a copy, circle E31 on postcard

Brushless Generator Bulletin

Characteristics of Allis-Chalmers high-speed, packaged brushless synchronous generators in 40 to 300-kw rating which provide new dependability, minimum maintenance, constant voltage and no sparking are described in a new four-page bulletin.

To get a copy, circle E32 on postcard

Helicopter Rig Booklet

How The National Supply Company's new Type 4-10 helicopter rig is disassembled into components weighing no more than 4,000 pounds is explained in a new 24-page illustrated booklet. Large exploded views on a 16 x 22-inch foldout show the components of the first drilling rig designed for transportation into remote areas.

To get a copy, circle E33 on postcard

Gas Well Equipment Folder

A four-page folder on four gas well equipment units is available from Graver Tank & Manufacturing Co. The folder contains illustrations of the four units, Graver Glycodrator, Graver Condensaver, Graver Koldex Unit and Graver Indirect Heaters, as well as charts and descriptive information for the equipments use.

To get a copy, circle E34 on postcard

Machinery Brochures

A series of new brochures on all Mid-Continent machinery is now offered by Mid-Continent Supply Co. Each brochure contains a complete description of the product including pictures and diagrams showing design features of parts and assemblies. Specifications, dimensional layouts and power flow diagrams are shown where applicable.

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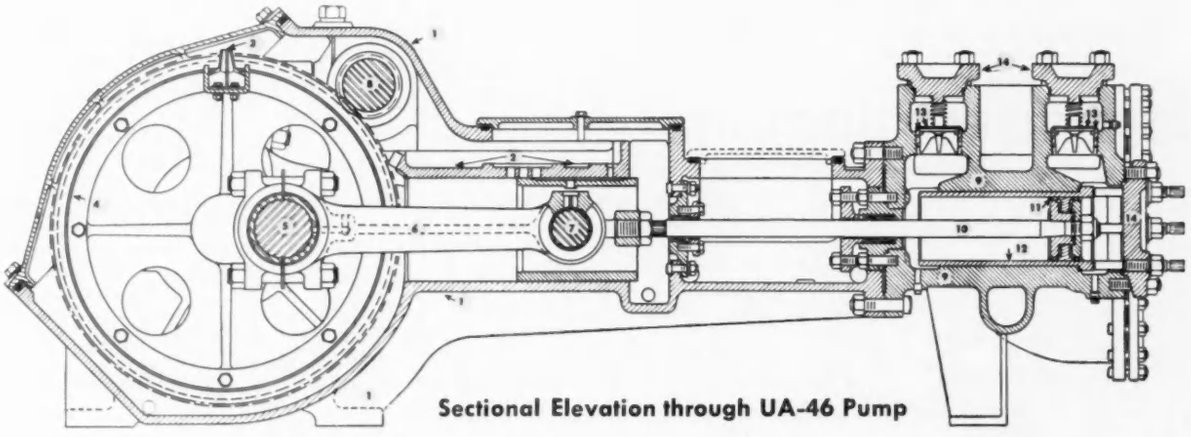
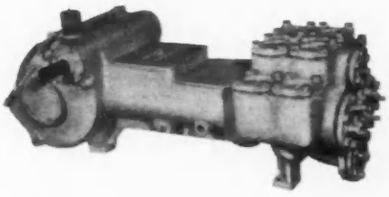
Ever look inside a

Bethlehem Duplex Power Pump?



Sectional Elevation through UA-46 Pump

1) Frame—one piece alloy-iron casting, rib-reinforced
2) Oil Chest—"heart" of the controlled-gravity-flow lubrication system
3) Oil Scraper—collects lubricant from gear rim to supply oil to all parts of power end
4) Main Gear—removable continuous-tooth herringbone
5) Crank Shaft—steel casting, normalized and tempered
6) Connecting Rod—normalized and tempered steel; H-section design
7) Crosshead Pin—alloy steel, hardened and ground
8) Pinion Shaft—heat-treated forged steel with integral pinion gear
9) Fluid-End Casting—moly-iron, steel, or aluminum-bronze
10) Piston Rods—steel, stainless steel, or aluminum-bronze; API taper or straight shank
11) Pistons—chrome-iron snap-ring, composition-cup, or slush type
12) Liners—interchangeable; alloy cast iron, hardened aluminum-bronze, or special order materials
13) Valves and Seats—hardened steel, aluminum-bronze, slush-type, or Nylon disc; interchangeable
14) Valve Covers and Cylinder Heads—moly-iron, steel, or aluminum-bronze



Inside and out, the durability of our U-series pumps is plainly evident. Solidly built for continuous operation at full load, these heavy-duty pumps are designed to give long and economical service in many kinds of applications:

- Waterflooding, disposal, and supply systems
- Mud transfer and general drilling service
- Crude oil pipeline and gathering
- Products, LPG, and oil-processing service

Ask our nearest office or store for complete details. Or write for descriptive literature.

There's a size for every job. Choose between the U-33, UA-46, and U-510

Capacities: 155 to 13,500 BPD
Piston-Rod Loads: 2,400 to 12,000 lb
Pressures: 340 to 1,698 psi

For higher pressures, investigate Bethlehem's Triplex pumps, the TP-3, TP-4, and TP-6

Capacities: 100 to 9,565 BPD
Plunger Loads: 3,580 to 10,000 lb
Pressures: 438 to 3,183 psi

BETHLEHEM STEEL COMPANY
SUPPLY DIVISION
General Offices: 21 E. Second St., Tulsa, Okla.
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Oil Field Engines

A 24-page illustrated brochure covering "GM Diesel Oil Field Engines" is now available from the Detroit Diesel Engine Division, General Motors. The new 24V-71 power unit is illustrated and described.

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Tubing Joint Data

Tubing joint engineering data on all recognized types of joints is included in a technical bulletin DS-59D just released by Hardy-Griffin Engineering Corporation. Simple formulas for calculating running clearance in casing for multiple strings are included.

To get a copy, circle E37 on postcard

Pumping Unit Brochure

An illustrated brochure describing the new Axelson Duo-Hydrax hydraulic pumping unit for the production of dual completed wells is now available from Axelson Division, U.S. Industries, Inc. Includes product description, production capabilities, hydraulic circuitry and the advantages incorporated into the unit design.

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Offshore Barge Booklet

A brochure giving complete information, specifications and complete list of equipment facilities on the Offshore Barge "Magic" is now available from Commonwealth Oil Company.

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